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NASA GLENN RESEARCH CENTER

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The NASA Glenn Research Center:

An Economic Impact Study Fiscal Year 2013

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CENTER FOR ECONOMIC DEVELOPMENT

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EXECUTIVE SUMMARY

- NASA Glenn is located at Lewis Field, a 300-acre site adjacent to Cleveland Hopkins International Airport. NASA Glenn's physical plant includes more than 150 buildings that contain a unique collection of world-class laboratories and test facilities. Since the groundbreaking for the Aircraft Engine Research Laboratory of the National Advisory Committee for Aeronautics (forerunner to NASA) on January 23, 1941, more than $680 million has been invested in NASA Glenn's physical plant. The estimated replacement cost is approximately $2.6 billion. The Lewis Field site and its Plum Brook Station, located in Sandusky, Ohio, is 50 miles west of Cleveland, each host large-scale facilities that are uniquely and specifically designed to test aviation and spaceflight hardware.

- During the period covered in this report, NASA Glenn has several leadership roles that are critical to programs and projects in all of NASA's missions: Exploration, Science, Space Operation, and Aeronautics Research. Within the **Human Exploration & Operations mission portfolio** NASA Glenn provided engineering and technical services and performed a variety of analyses and integration tasks to support development of the Space Launch System (SLS) and the Orion Multi-Purpose Crew Vehicle; led aspects of the Human Research Program, which performs research in support of astronaut health; developed next-generation systems that support humans reaching farther into space, and initiated projects within the Advanced Exploration Systems (AES) program, which is contributing technological advancements for future robotic and human spaceflight missions beyond low Earth orbit. NASA Glenn is leading AES projects in spacecraft fire safety, advanced modular power systems, and power, avionics, software, and communication technologies for extra-vehicular activity applications.

- NASA Glenn's **Science** mission support included managing the Radioisotope Power Systems Program and developing associated technologies; co-managing (with the Department of Energy) the Advanced Stirling Radioisotope Generator (ASRG) project; managing the In-Space Propulsion Technology (ISPT) Program and developing its associated technologies including propulsion systems (e.g. solar electric propulsion), spacecraft bus (e.g. power, extreme environments), sample return, and re-entry; developing new scientific instruments and mission concepts for planetary surfaces (e.g. Venus, Mars) and Earth science (e.g. fresh water); and supporting NASA Headquarters with assessments and panel membership for Planetary Science which includes high altitude balloon research, technology/tools coordination, and science advisory groups.

- In support of the **Aeronautics** mission**,** NASA Glenn continues to build on its world-class aeronautics' heritage through its leadership of a wide variety of fundamental research in subsonic, supersonic, and rotary aircraft, and through its program management efforts to support flight in any atmosphere at any speed and the enhancement of aviation safety. A vast array of research and technologies in support of these areas is performed by NASA Glenn.

- The report structure is as follows: Sections A and B provides an introduction and background for this report. Section C is an economic overview of NASA Glenn, including information related to employment and occupations, employee residences, payroll, expenditures, awards to academia and other institutions, revenues,

and taxes paid by NASA Glenn employees. Section D provides estimates of the economic impact generated by NASA Glenn for an eight-county Northeast Ohio region and the state of Ohio during FY 2013. This report is an update of several earlier studies in which NASA Glenn's economic impact on Northeast Ohio and Ohio was estimated.

ECONOMIC IMPACT GENERATED BY NASA GLENN RESEARCH CENTER SPENDING

- Economic impact is an analytical approach used to estimate the economic benefits generated by an entity for an affected region. This study uses an input-output (I-O) model to estimate the effect of NASA Glenn's spending on the economies of Northeast Ohio (NEO) and Ohio. This model measures economic impact in terms of growth in output (sales), value added (output less intermediary goods), number of new and supported jobs, the increase in labor income, and tax revenues. This year, the Center used an improved methodology to measure NASA Glenn's impact on Northeast Ohio and Ohio. The results of this research can be compared to previous reports and account for these changes. The changes in methodological approach are explained in the Methodology section of this report (Section D.1). The table below summarizes NASA Glenn's economic impact on Northeast Ohio and the state of Ohio during FY 2013.

Economic Impact	Northeast Ohio	State of Ohio
Output	$1,191 million	$1,392 million
Value Added	$744.8 million	$828.2 million
Employment	6,044 jobs	7,414 jobs
Labor Income	$464.2 million	$531.3 million
Taxes	$82.9 million	$103.1 million

Note: According to the new methodology, labor income accounts for commuter spending—people who live outside of the study area and spend only a portion of their income in the region. In this study, direct value added impact was assessed as a percentage of output; in previous studies we accounted only for labor income as a direct value added impact.

- NASA Glenn's activities in Northeast Ohio in fiscal year (FY) 2013, stimulated by $625.2 million in revenues originating primarily from outside of the region, generated an increased demand in output (sales) valued at $1,191 million for goods and services produced in the region. In other words, value added output increased by $744.8 million as a result of NASA Glenn's activities. In addition, 6,044 jobs were created and supported in the region, and labor income in Northeast Ohio increased by $464.2 million. NASA Glenn operations also generated $82.9 million in local, state, and federal taxes.

- NASA Glenn's activities in Ohio in FY 2013, stimulated by $625.2 million in revenues originating primarily from outside of the state, generated an increased demand in output (sales) for products and services produced across the state (valued at $1,392 million). Value added output increased by $828.2 million as a result of NASA Glenn's activities. In addition, 7,414 jobs were created and supported in Ohio and labor income across the state increased by $531.3 million. NASA Glenn's activities also generated $103.1 million in local, state, and federal taxes.

- Industries deriving the most benefit from direct NASA Glenn spending included education, manufacturing, power generation, business support services, administrative and support services, maintenance and repair construction, scientific research and development services, and other professional and technical services.
- Industries deriving the most benefit from spending by NASA Glenn personnel and other workers paralleled typical consumer spending patterns. These industries included food services, insurance services, commercial banks, miscellaneous retailers, real estate and rental services, and hospitals and healthcare offices.

NASA Glenn Research Center: An Overview

- In FY 2013, NASA Glenn employed 1,664 civil servants, declining from the previous year by 5 employees. From FY 2009 to FY 2013, NASA Glenn's total civil service employment increased by 0.8% (14 employees), with employment peaking in 2011, at 1,711 employees.

- NASA Glenn employs highly educated and highly skilled civil service workers. In FY 2013, 83% of NASA Glenn's employees possessed bachelor's degrees or higher.[1] Of all NASA Glenn's civil service employees, 18% held doctoral degrees, 36% held master's degrees, and 30% held bachelor's degrees. Compared to FY 2012, the level of educational attainment of NASA Glenn's civil service employees has increased slightly. The number of employees holding bachelor's degrees or higher increased 1% between FY 2012 and FY 2013. The increased number of highly educated employees between FY 2012 and FY 2013 mirrors the increase in the share of scientists and engineers hired by NASA Glenn during this same timeframe. NASA Glenn aims to increase the share of its civil servant workforce dedicated to research and technology while reducing the cost of support personnel.

- The largest occupational category in FY 2013 was scientists and engineers, which accounted for 68% of the civil service employees in that fiscal year. The share of scientists and engineers at NASA Glenn has gradually increased since FY 2009 from 63% (1,040 employees) to 68% (1,124 employees) in FY 2013. This continues a long-term shift in the employment share of scientists and engineers over the last 10 years. Between FY 2004 and FY 2013, the share of scientists and engineers has increased from 57% to 68%.

- Total compensation for NASA Glenn's civil service employees was $224.1 million in FY 2013. Total compensation in this report includes both payroll ($176.3 million) and employee benefits ($47.8 million). Total compensation between FY 2012 and FY 2013 dropped by $5.1 million (-2.2%) when adjusted for inflation.[2] Additionally, between FY 2009 and FY 2013, total compensation fell by $7.8 million (-3.4%) when adjusted for inflation, even as nominal spending increased.[3] Total payroll, which stood at $224.1 million in 2013, decreased by $5.2 million (-2.9%) between FY 2012 and FY 2013 when adjusted for inflation.[4] Between FY 2009 and FY 2013, payroll dropped by $15.1 million (-7.9%), adjusting for inflation.[5]

- NASA Glenn's total revenue in FY 2013 was $655.1 million. In the last 5 years, NASA Glenn's total revenue was lowest in FY 2013; with the exception of an increase in FY 2011, revenue has declined steadily since FY 2009. FY 2013 continued this trend with revenues decreasing by $32.6 million (-4.7%) from the previous year. Overall, NASA Glenn's revenue has decreased by $108.6 million (-14.2%) from FY 2009 to FY 2013 (in nominal dollars).[6]

[1] Total does not equal sum of components due to rounding.

[2] Total nominal compensation decreased by 0.9% ($2.1 million) between FY 2012 and FY 2013.

[3] Total nominal compensation increased by 4.9% ($10.4 million) between FY 2009 and FY 2013.

[4] Total nominal payroll decreased by 1.6% ($2.9 million) between FY 2012 and FY 2013.

[5] Total nominal payroll decreased by 0.1% ($0.1 million) between FY 2009 and FY 2013.

[6] Nominal dollars refer to dollars that have not been adjusted for inflation.

- In FY 2013, NASA Glenn allocated its spending of $395.9 million to vendors in 48 states, Washington, D.C., Puerto Rico, and eleven foreign countries. Compared to its total expenditures of $434.7 million in FY 2012, NASA Glenn reduced its expenditures by 8.9% in FY 2013 ($38.8 million in nominal dollars). Total expenditures decreased by 25.4% ($135 million) between FY 2009 and FY 2013.

- In FY 2013, Ohio, and more specifically Cuyahoga County, was the largest beneficiary of expenditures, receiving $275 million of NASA Glenn's total expenditures. Despite a $15.3 million decrease (in nominal dollars) compared to FY 2012, the share of NASA Glenn's expenditures in Ohio increased from 66.7% in FY 2012 to 69.4% in FY 2013.

- In addition to Ohio, three states (California, Maryland, and Virginia) each received over $9 million, or at least 2.4% of NASA Glenn's total expenditures during FY 2013. California received $21.2 million (5.4%), Maryland $17.1 million (4.3%), and Virginia $9.6 million (2.4%), making them the second- , third-, and fourth-largest beneficiaries of NASA Glenn spending. Though posting the highest spending, each of these states saw nominal declines in spending when compared to FY 2012 of $3.1 million, $4.3 million, and $0.9 million, respectively.

- In FY 2013, NASA Glenn increased its expenditures in foreign countries compared to FY 2012, to $0.8 million, representing only 0.2% of NASA Glenn's total spending in FY 2013. The largest beneficiaries were Canada with $0.4 million and the United Kingdom with $0.2 million.

- Of NASA Glenn's total expenditures in Ohio, Northeast Ohio received $223.8 million, which accounted for 81.5% of Ohio spending in FY 2013. Northeast Ohio also accounted for 56.5% of NASA Glenn's total spending in FY 2013. Cuyahoga County dominated NASA Glenn spending in Northeast Ohio with 98.3% of said spending. Additionally, Cuyahoga County represented 80.1% of spending in Ohio, and 55.6% of total NASA Glenn spending in FY 2013.

- NASA Glenn Research Center awards funding to colleges, universities, and other nonprofit institutions in the form of R&D contracts and grants for assisting NASA in their research and development activities. In FY 2013, NASA Glenn awarded $16.2 million to colleges and universities in 32 states and Puerto Rico. Compared to FY 2012, this represented a reduction of academic grants from NASA Glenn of $6.1 million (-27.4% in nominal dollars).

- Universities in four states—Ohio, Massachusetts, California, and Indiana—received over $1 million in funding from NASA Glenn in FY 2013. The academic funding awarded in these four states collectively accounted for 56.1% of the total grants in FY 2013. Academic institutions in Ohio received $4.3 million, which accounted for the largest share (26.5%) of NASA Glenn's academic awards in FY 2013. NASA Glenn's academic awards to Ohio decreased by 12.5% (-$0.6 million) between FY 2012 and FY 2013.

- Academic institutions in Northeast Ohio received $2.5 million in FY 2013. Northeast Ohio academic institutions accounted for both 15.5% of NASA Glenn's total academic awards and 58.6% of all academic grants given in Ohio. NASA Glenn slightly reduced its awards to the universities and academic institutions in Northeast Ohio by 6.9% (-$0.2 million) compared to FY 2012. NASA Glenn's funding to Ohio academic institutions located outside of Northeast Ohio's seven counties decreased by 19.3% (-$0.4 million) compared to FY 2012.

- NASA Glenn continues to be an important institution influencing the economies of both Northeast Ohio and the state of Ohio. NASA Glenn's employees are part of the knowledge-intensive labor force that advances the nation, generates wealth in the region, and attracts other creative labor to reside in Ohio.

A. INTRODUCTION

This report presents an analysis of the economic impact of the National Aeronautics and Space Administration's John H. Glenn Research Center (NASA Glenn) during its fiscal year (FY) 2013. It uses an input-output model, which reflects the buy-sell relationships among industries, the household sector, and the government sector in a region, to estimate the effect of NASA Glenn's spending on the economies of both Northeast Ohio and the state of Ohio.[7] This model assesses economic impact in terms of growth in total output (sales); value added (output less intermediary goods); household earnings, number of new jobs, and taxes.[8]

The report also provides an overview of NASA Glenn and describes some of its research and development (R&D) activities. It looks at changes in NASA Glenn's employees in terms of payroll, occupation, and place of residence.

The report further provides information on NASA Glenn's expenditures and revenues, awards to academic institutions, and taxes contributed by employees.

The analysis was conducted by the Center for Economic Development at Cleveland State University's Maxine Goodman Levin College of Urban Affairs. This FY 2013 report is an update to previous studies published in 1996, 2000, 2005, and annually from 2007 through 2013.[9]

[7] For purposes of this study, Northeast Ohio is defined as Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit Counties.

[8] Output impact reflects the total value of all additional goods and services produced in the economy. For example, the output economic impact includes the total value of all professional scientific and technical services and all intermediary goods created to secure delivery of the scientific services. Value added impact reflects the value of only additional output produced in the region, which is calculated as total sales less intermediary goods not sold as final products. For example, the value added impact will account for the value of all professional scientific and technical services, excluding intermediary goods produced to deliver these services. Such intermediary goods include research supplies, utilities, research services of intermediary steps of research, etc.

[9] All previous studies can be found on the Center for Economic Development's website: http://urban.csuohio.edu/economicdevelopment/publications/

B. NASA GLENN RESEARCH CENTER: BACKGROUND

The NASA Glenn Research Center, in partnership with U.S. industry, universities, and other government institutions, develops critical systems' technologies and capabilities that address national aerospace priorities. The Center is distinguished by a unique blend of aeronautics, space flight, and project management expertise and experience. Its work is focused on technological advances in space flight systems, aero-propulsion, space propulsion, power systems, nuclear systems, advanced communications, materials for use in extreme environments, and targeted technology that enable human health in space. Its research, technology, and capability development efforts are vital to advancing exploration of our solar system and beyond while maintaining global leadership in aeronautics.

B.1. NASA GLENN TEST FACILITIES

NASA Glenn is located at Lewis Field, a 300-acre site adjacent to Cleveland Hopkins International Airport. NASA Glenn's physical plant includes more than 150 buildings that contain a unique collection of world-class laboratories and test facilities. Since the groundbreaking for the Aircraft Engine Research Laboratory of the National Advisory Committee for Aeronautics (forerunner to NASA) on January 23, 1941, more than $680 million has been invested in NASA Glenn's physical plant. The estimated replacement cost is approximately $2.6 billion.

NASA Glenn's Plum Brook Station, located in Sandusky, Ohio, is 50 miles west of Cleveland. Plum Brook and the Lewis Field site each host several large test facilities which use cryogenic fluids (gases frozen to their liquid state). Because working with large amounts of cryogenic fluids is inherently dangerous, the Station's 6,400 acres uniquely allow for the safe testing of spacecraft and hypersonic vehicles in realistic operating conditions from launch to planetary operations. Most of these capabilities are world-unique, including the largest space simulation chamber, the largest mechanical vibration table, the most powerful resonant acoustic test chamber, the largest electromagnetic test chamber, the largest space simulation chamber which can test in planetary dust, the largest liquid hydrogen-capable space simulation chamber, the only cold soak start/restart rocket engine test facility, and the only clean air hypersonic tunnel. Since 2000, over $567 million has been invested in Plum Brook station. The total replacement cost of all Plum Brook Station facilities is approximately $4 billion.

B.2. NASA GLENN MISSION AREAS SUPPORTING NASA THEMES

During the period covered in this report, NASA Glenn has had several leadership roles that are critical to programs and projects in all of NASA's missions: Exploration, Science, Space Operation, and Aeronautics Research.

Human Exploration & Operations (Human Spaceflight to the International Space Station (ISS), Moon and Beyond).

- Managing the European Service Module (ESM) and its integration within the Orion MPCV Program. The ESM vitally provides power, propulsion, and communications for Orion's Crew Module (CM).

- Provide the Solar Electric Propulsion Module for the Asteroid Redirect/Retrieval Mission. Propose extension of this technology and vehicle for Human exploration Cargo transfer vehicles.
- Applying human spaceflight engineering and technical capabilities to perform a variety of analysis and integration tasks to support development of the Space Launch System (SLS) and the Orion Multi-Purpose Crew Vehicle.
- Conducting critical-path environmental testing of the integrated Orion spacecraft at Plum Brook Station. Contributing to the Human Research Program, which performs research and technology.
- Leading the operation and utilization of new, advanced communications technology, including the SCaN Testbed - a demonstration on the International Space Station of software-defined radios.
- Conducting space life and physical science research (specifically combustion science and fluid physics) on the International Space Station, from research objective definition to experiment equipment provision and operation.
- Developing next-generation systems that support humans in space via specific projects within NASA's Advanced Exploration Systems (AES) program. NASA Glenn is leading AES projects to make advancements in spacecraft fire safety, advanced modular power systems, and power, avionics, software, and communication technologies for extra-vehicular activity applications.
- Managing several research and advanced technology development projects on the ISS and on Earth, in support of human exploration.
- Supporting safe and reliable operation of the International Space Station's electrical power system.

Technology

- Lead the development of Solar Electric Propulsion technology, and the Solar Electric Propulsion Module, for Technology Demonstration Missions and the Asteroid Redirect/Retrieval Mission.
- Lead development of technologies for cryogenic fluids transfer and storage, for both application to the Space Launch System and future transportation systems.
- Provide propulsion system analysis and testing of "green" fuels for satellite missions.
- Manage and develop kilo-watt class nuclear power systems for in-space and surface power.
- Test small satellite infusion of propulsion and power generation technologies using micro-sats and Cube-sats.

Science

- Managing the Radioisotope Power Systems Program and developing associated technologies. Radioisotope Power Systems enable scientific missions where conventional power systems such as solar power or batteries are impractical. The Advanced Stirling Converter (ASC) and Stirling Radioisotope Generators (SRGs) are examples of these technologies.
- Manages Department of Energy production of radioisotope materials and fuel for NASA space missions.
- Develop and promulgate NASA-wide strategy for nuclear power and propulsion systems.
- Develop with industry ion-grid solar electric propulsion thrusters and PPUs to be provided as NASA equipment to Discovery Space Science Missions.
- Managing the In-Space Propulsion Technology (ISPT) Program and developing its associated technologies including

propulsion systems (e.g. solar electric propulsion), spacecraft bus (e.g. power, extreme environments), sample return, and re-entry. Conducting system and mission studies to validate benefits.

- Developing new scientific instruments and mission concepts for planetary surfaces (e.g. Venus, Mars) and Earth science (e.g. fresh water).
- Supporting NASA Headquarters with assessments and panel membership for Planetary Science including high altitude balloon research, technology/tools coordination, and science advisory groups.

Aeronautics Research

- Continuing to improve upon Glenn's world-renowned aeronautics' heritage by concentrating research and program management efforts on the mastery of the principles of propulsion, flight in any atmosphere at any speed and the enhancement of aviation safety.
- Supporting the ARMD Research Thrusts in: Safe efficient growth in global operation, Transition to Low Carbon Propulsion, Innovation in Commercial Supersonic Aircraft, Real Time, System-wide Safety Assurance, Ultra-Efficient Commercial Vehicles, Assured Autonomy for Aviation Transformation
- Providing technical project management leadership for the Advanced Air Vehicle Program, and conducting research for the following projects:

Advanced Air Vehicles Program

- Conducts fundamental research to improve aircraft performance and minimize environmental impacts from subsonic air vehicles.
- Develops and validates tools, technologies and concepts to overcome key barriers, including noise, efficiency, and safety for rotorcraft vehicles.
- Explores theoretical research for potential advanced capabilities and configurations for low boom supersonic aircraft.
- Conducts research to reduce the timeline for certification of composite structures for aviation.
- Ensures the strategic availability, accessibility, and capability of a critical suite of aeronautics ground test facilities to meet Agency and national aeronautics testing needs.
- Glenn provides technical project management leadership for the Advanced Air Vehicle Program, and conducts research for the following projects:

  - **Advanced Air Transport Technology Project**
    Will clearly define the most compelling technical challenges facing the air transport industry as envisioned for the "N+3" horizon. The research will explore and advance knowledge, technologies, and concepts to enable giant steps in energy efficiency and environmental compatibility resulting in less fuel burned and less direct impact on the atmosphere. Potential new safety considerations associated with these advanced technologies and concepts will be identified.

  - **Revolutionary Vertical Lift Technology (RVLT) Project**
    Will clearly define the most compelling technical challenges facing the rotorcraft and vertical lift communities. The ability to leverage vertical flight and hover, with vastly improved noise, efficiency, and safety, has potential to lead to new missions and markets affecting human and cargo transportation and delivery, increased safety and security in constrained landscapes, and sustained and effective surveillance for natural and manmade disasters.

- **Advanced Composites (AC) Project**
  Is addressing new test protocols and methods to reduce the development and certification timeline for composite materials and structures, moving away from practices primarily based on testing. Research will focus on the development and use of high fidelity and rigorous computational methods, improved test protocols, and standardized inspection techniques to shorten the timeline to bring innovative composite materials and structures to market.

- **High Speed (HS) Project**
  Vehicle research includes tools, technologies, and knowledge that will help to eliminate today's technical barriers preventing practical, commercial supersonic flight. These barriers include: sonic boom; supersonic aircraft fuel efficiency; airport community noise; high altitude emissions; prediction of vehicle control, operation and performance; and the ability to design future vehicles in an integrated, multidisciplinary manner.

- **Aeronautics Evaluation and Test Capabilities (AETC) Project**
  Will combine the research, analysis, and test capabilities necessary to achieve future air vehicle development and operations as described above. This integrated approach will require the efficient and effective investment, use, and management of complementary high-end computing capabilities necessary for advanced analyses, wind tunnels, propulsion test facilities, and other NASA-unique test facilities and ground testing capabilities.

Integrated Aviation Systems Program

- Conducts research on promising concepts and technologies at an integrated system level.
- Explores, assesses, and demonstrates the benefits of promising technologies in a relevant environment.
- Conducts research into environmentally responsible aviation and unmanned system integration into the national airspace.
- Supports flight research needs across the ARMD strategic thrusts, programs and projects.
- Glenn provides technical project management leadership for the Integrated Aviation Systems Program, and conducts research for the following projects:

  - **Low Boom Flight Demonstrator Project**
    ARMD will conduct focused planning of a new project to develop a Low Boom Flight Demonstrator. The objective of this project will be to mature key low boom technologies that have been developed in the Fundamental Aeronautics Program through demonstration of associated benefits in a realistic flight environment. This will be accomplished by flight validation of design tools and technologies of an aircraft with sonic boom levels acceptable for civil supersonic overland flight.

  - **Flight Demonstrations and Capabilities (FDC) Project**
    ARMD is increasing the emphasis on flight related research, and the Integrated Aviation Systems Program (IASP) will reflect this emphasis by combining the flight test portion of the former Aeronautics Test Program with flight research and demonstrations from ARMD in the Flight Demonstrations and Capabilities (FDC) Project. This will consist of two distinct components; Flight Capabilities and

Flight Demonstrations. The underlying philosophy of this project will be to foster a focus on innovation and flexibility through embracing key attributes of the best practices of the flight research community (e.g. NASA X-planes, Boeing's ecoDemonstrator with frequent flight demonstrations and disciplined schedules).

- **For FY15:**
  Environmental Responsible Aircraft (ERA): Propulsion Technology Sub-element focused on developing and demonstrating, in collaboration with industry and other government agencies, integrated systems technologies that enable industry to meet the NASA goals for reduction in aircraft emissions, noise, and fuel burn for the 2025 timeframe.

- **For FY15 - FY16:**
  Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS): contributes capabilities that reduce the technical barriers related to the safety and operational challenges associated with enabling routine UAS to the NAS. NASA Glenn has primary responsibility for the communication technology sub-element for the UAS in the NAS.

Transformative Aeronautics Concepts Program

- Cultivates multi-disciplinary, revolutionary concepts to enable aviation transformation and harnesses convergence in aeronautics and non-aeronautics technologies to create new opportunities in aviation.
- Knocks down technical barriers and infuses internally and externally originated concepts into all six strategic thrusts identified by ARMD, creating innovation for tomorrow in the aviation system.
- Provides flexibility for innovators to explore technology feasibility and provide the knowledge base for radical transformation.
- Glenn provides technical project management leadership for the Transformative Aeronautics Concepts Program, and conducts research for the following projects:

  - **Convergent Aeronautics Solutions (CAS) Project**
    Will use short-duration activities to establish early-stage concept and technology feasibility for high-potential solutions to thrust-aligned major system-level challenges that require NASA and the aviation community to think beyond current concepts, architectures and relationships. The focus of CAS will be on merging traditional aeronautics disciplines with advancements driven by the non-aeronautics world to advance innovative solutions to these barriers to open and enable new capabilities in commercial aviation.

  - **Transformative Tools and Technology (TTT) Project**
    Will develop new computer-based tools, models, and associated scientific knowledge that will provide first-of-a-kind capabilities to analyze, understand, and predict performance for a wide variety of aviation concepts. These revolutionary tools will be applied to accelerate NASA's research and the community's design and introduction of advanced concepts. TTT will also perform fundamental development of technologies, applicable across ARMD mission programs, such as the understanding of new types of strong and lightweight materials that are vital to aviation.

- **Leading Edge Aeronautics Research for NASA (LEARN) Fund for Non-NASA Researchers**
  The LEARN Fund annually provides opportunities for innovators from outside NASA to perform research, analysis, and proof-of-concept development of their novel ideas that have the potential to meet national aeronautics needs. The Fund provides resources for early-stage efforts not currently supported by ARMD Programs and Projects, with the goal of infusing promising concepts into the ARMD research portfolio or into NASA's Small Business Innovation Research (SBIR) program for further development. It is open to all domestic researchers. International partners may collaborate with LEARN research teams, but are not eligible to receive funding. NASA civil servants have a similar opportunity through the ARMD Seedling Fund, and are explicitly prohibited from competing for LEARN funding.

Airspace Operations and Safety Program:

- Develops and explores fundamental concepts, algorithms, and technologies to increase throughput and efficiency of the National Airspace System safely.
- Provides knowledge, concepts, and methods to the aviation community to manage increasing complexity in the design and operation of vehicles and the air transportation system.
- Glenn provides technical project management leadership for the Airspace Operations and Safety Program, and conducts research for the following projects:

- **Airspace Technology Demonstrations (ATD) Project**
  Provide a strong focus from the current Airspace Systems Program technical content delivering a limited, yet impactful set of transition-able benefits for NextGen covering gate-to-gate elements. This project contributes to the Safe and Efficient Growth in Global Aviation strategic thrust.

- **Technologies for Assuring Safe Energy and Attitude State activities**
  Will deliver specific R&D products to industry as defined through community planning (Commercial Aviation Safety Team).

- **SMART-NAS Test-Bed for Safe, Trajectory-Based Operations (SMART-NAS) Project**
  A strong focus will be placed on the SMART-NAS Project to deliver an evaluation capability, critical to the Air Traffic Management community, allowing full NextGen and beyond NextGen concepts to be assessed and developed.

- **Safe, Autonomous Systems Operations (SASO) Project**
  Will develop autonomous capability in support of the Enable Assured Machine Autonomy for Aviation strategic thrust. Project deliverables will focus initially on development of concepts, requirements, and architectures to accept the broadest set of innovative concepts.

C. NASA GLENN RESEARCH CENTER: ECONOMIC OVERVIEW

This section presents an economic overview of the NASA Glenn Research Center during FY 2013. Changes between FY 2009 and FY 2013 are described in terms of payroll, revenues, expenditures, academic awards, occupational distribution, number of employees, employee residence locations, and income taxes paid by NASA Glenn employees.

C.1. EMPLOYMENT AND OCCUPATIONS

The labor force of NASA Glenn Research Center consists of two components: civil service employees and local contractors. Federal laboratories commonly contract for specific tasks and services, which also allows for more flexibility in their labor costs. The number of contracted employees can be adjusted more quickly to align with the varying amount and nature of the laboratories' work.

In contrast, the NASA civil servant cadre has been relatively constant in number to retain long-term core expertise, which is especially important for efficient and effective execution of aerospace projects that often last many years from conception through completion. Over the last five years, the civil service workforce at Glenn had an average employment of 1,668.

Table 1 shows the total number of NASA Glenn's civil service employees and the shares of four occupational categories between FY 2009 and FY 2013. In FY 2013, NASA Glenn had 1,664 civil service employees. Within the past five years, Glenn civil service employment peaked in FY 2011 with a total of 1,711 employees. NASA Glenn's employment increased between FY 2009 and FY 2011 by 3.7%. Since FY 2011, however, Glenn civil service employment has decreased by 2.8% through the end of FY 2013. Over the last five fiscal years, NASA Glenn's civil employment has increased slightly by 0.8% (+14 employees).

Table 1. NASA Glenn Civil Service Employment Distribution by Occupational Category, FY 2009-FY 2013

Fiscal Year	Total	Occupational Category			
		Administrative Professional	Clerical	Scientists & Engineers	Technician
2009	1,650	20%	4%	63%	12%
2010	1,658	20%	4%	65%	11%
2011	1,711	20%	4%	65%	10%
2012	1,659	21%	4%	67%	9%
2013	1,664	21%	3%	68%	8%

Note: Table does not include local contractors.[10]

[10] A detailed listing of NASA Glenn's local contractors can be found at http://www.grc.nasa.gov/WWW/Procure/ContractorList/On-siteServiceContractorListing.htm

NASA Glenn's civil service employment consists of four occupational categories: clerical, technicians, administrative professionals, and scientists and engineers. The occupational structure of NASA Glenn's employment has undergone a subtle shift during the past five years.

The largest occupational category in FY 2013 was scientists and engineers, which accounted for 68% of the civil service employees in that fiscal year. The share of scientists and engineers at NASA Glenn has gradually increased since FY 2009 from 63% (1,040 employees) to 68% (1,124 employees) in FY 2013. This continues a long-term shift in the employment share of scientists and engineers over the last 10 years. Between FY 2004 and FY 2013, the share of scientists and engineers has increased from 57% to 68%.

The administrative professional group was the second-largest occupational category at NASA Glenn in all previous years studied. This category consistently accounted for about 20% of the total civil service employees during the study periods. Between FY 2011 and FY 2012, the share of the administrative professional group increased slightly from 20% to 21% and remained at that level for FY 2013.

The number of clerical staff accounted for 4% of the total civil service employees for each year from FY 2009 through FY 2012, dropping to 3% in FY 2013. This category has seen a decrease of 9 employees since FY 2009.

The number of technicians has decreased by 58 employees, from 198 in FY 2009 to 140 in FY 2013. The technician group accounted for 8% of NASA Glenn's civil service employment in FY 2013. The increase of scientists and engineers accompanied the loss of technicians over the years, with a 4-percentage point drop, from 12% to 8%, since FY 2009. Looking back further, this downward trend continues over the long-term with technicians accounting for 17% of the workforce in FY 2004.

NASA Glenn employs highly educated and highly skilled civil service workers. In FY 2013, 83% of NASA Glenn's employees possessed bachelor's degrees or higher. Of all NASA Glenn's civil service employees, 18% held doctoral degrees, 36% held master's degrees, and 30% held bachelor's degrees. Compared to FY 2012, the level of educational attainment of NASA Glenn's civil service employees has increased slightly. The number of employees holding bachelor's degrees or higher increased 1% between FY 2012 and FY 2013. The increased number of highly educated employees between FY 2012 and FY 2013 parallels the increase in the share of scientists and engineers hired by NASA Glenn during this same timeframe.

As Table 2 shows, NASA Glenn employed 1,643 on- or near-site contractors in FY 2013. During the past five years, NASA Glenn's employment of local contractors peaked in 2010 at 1,912. Since then, employment has dropped by 14% through FY 2013, with the largest drop-off occurring between FY 2011 and FY 2012 when employment dropped by 170. Between FY 2009 and FY 2013, total on- or near-site contractor employment has decreased by 252 or 13%.

The total number of NASA Glenn employees, including both civil service employees and local contractors, was 3,307 in FY 2013. The total labor force decreased by 7.9% from its peak in FY 2010 (3,570) to FY 2013 (3,307): NASA Glenn gained a net six civil service employees and lost 269 on- or near-site local contractors between FY 2010 and FY 2013. Overall, NASA Glenn's total labor force shrank by 7.1% over the past five years, from 3,545 in FY 2009 to 3,307 in FY 2013.

Table 2. NASA Glenn On- or Near-Site Contractors Employment, FY 2009-FY 2013

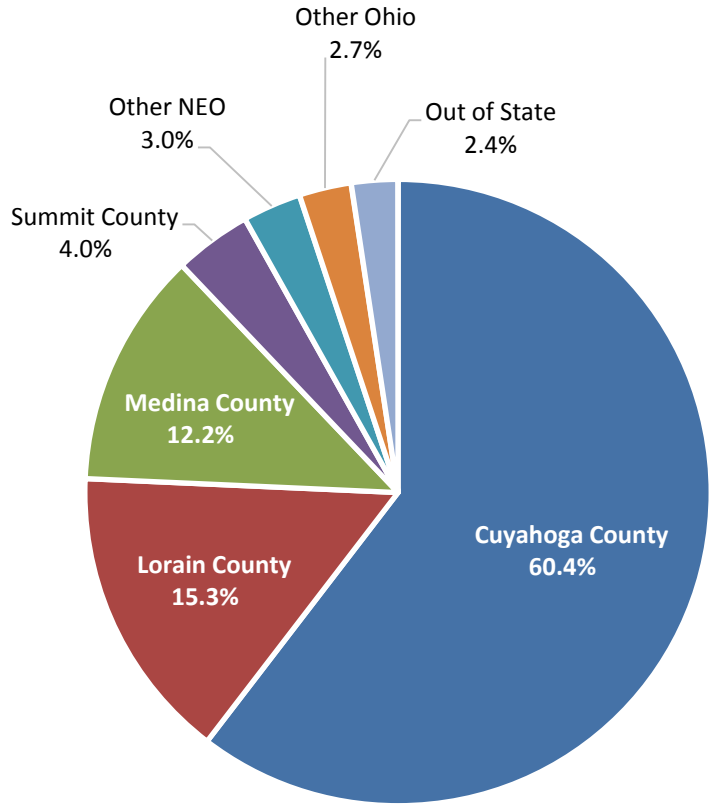
Fiscal Year	Employment of On- or Near-Site Contractors
2009	1,895
2010	1,912
2011	1,858
2012	1,688
2013	1,643

C.2. Place of Residence for Glenn Employees

NASA Glenn Research Center is located near Cleveland Hopkins International Airport in Cuyahoga County, Ohio. NASA Glenn also includes Plum Brook Station, located near Sandusky, Ohio, west of the main facility. Most civil service employees working at NASA Glenn live in Cuyahoga County or the other surrounding counties that comprise Northeast Ohio. Figure 1 shows the breakdown of employees' postal addresses by geographic region. During FY 2013, almost all of NASA Glenn's civil service employees (1,579 employees; 94.9%) resided in Northeast Ohio.

Specifically, 60.4% of civil servants (1,005 employees) lived in the same county as NASA Glenn. NASA Glenn employees also lived in Lorain (254 employees; 15.3%), Medina (203 employees; 12.2%), Summit Counties (66 employees; 4.0%), and small numbers in other surrounding counties. Of the total 1,664 civil service workers employed by NASA Glenn in FY 2013, 45 employees (2.7%) lived elsewhere in Ohio, while forty employees (2.4%) had postal addresses in other states. Compared to FY 2012, the number of NASA Glenn employees who reside in Cuyahoga County has decreased by ten (-1%). Those classified as living out of state, on the other hand, increased by 34% (10 employees) between FY 2012 and FY 2013.

Figure 1. NASA Glenn Civil Service Employees by Location of Residence, FY 2013



NASA Glenn's civil service employees' places of residence of are shown by occupation in Table 3. Cuyahoga County served as the place of residence for the highest share of employees in each occupational category. More than 59% of NASA Glenn's scientists & engineers, administrative professionals, and clerical employees lived in Cuyahoga County in FY 2013. Technicians were the least likely to live in Cuyahoga County, with only 55.5% residing there, while clerical employees were the most likely, with 61.9% in the county.

Approximately 4% to 5% of NASA Glenn's technicians, administrative professionals, and scientists and engineers have postal addresses outside of Northeast Ohio. Civil service employees engaged in clerical work were most likely to live in Northeast Ohio, with only 2.4% living outside of the region. Scientists and engineers were the least likely to live in Northeast Ohio, and, in fact, most likely among the occupations to live outside of Ohio entirely (3.3%)

Table 3. NASA Glenn Civil Service Employees by Occupation and Place of Residence, FY 2013

Residence	Administrative Professional	Clerical	Scientists & Engineers	Technicians	Total
Northeast Ohio	**95.4%**	**97.6%**	**94.6%**	**95.5%**	**94.9%**
Cuyahoga County	59.5%	61.9%	61.2%	55.5%	60.4%
Lorain County	18.5%	19.1%	14.0%	17.3%	15.3%
Medina County	11.0%	11.9%	12.2%	15.5%	12.2%
Summit County	4.9%	0.0%	3.9%	2.7%	4.0%
Geauga County	0.3%	4.8%	1.1%	2.7%	1.1%
Portage County	0.9%	0.0%	1.2%	0.9%	1.1%
Lake County	0.3%	0.0%	1.1%	0.9%	0.9%
Remainder of Ohio	**4.1%**	**2.4%**	**2.1%**	**4.6%**	**2.7%**
Out of State	**0.6%**	**0.0%**	**3.3%**	**0.0%**	**2.4%**

Note: Northeast Ohio component counties sorted by total.

C.3. PAYROLL

Total compensation for NASA Glenn's civil service employees was $224.1 million in FY 2013.[11] Total compensation in this report includes both payroll ($176.3 million) and employee benefits ($47.8 million). Total compensation between FY 2012 and FY 2013 dropped by $5.1 million (-2.2%).[12] Additionally, between FY 2009 and FY 2013, total compensation fell by $7.8 million (-3.4%) even as nominal spending increased during that period.[13]

Total payroll, which stood at $224.1 million in 2013, decreased by $5.2 million (-2.9%) between FY 2012 and FY 2013.[14] Between FY 2009 and FY 2013, payroll dropped by $15.1 million, for a decrease of 7.9%.[15]

The relationship between the change in total compensation and the change in payroll indicate that employee benefits, over the timeframe measured, have increased at a rate that partially offsets the declining real value of payroll. In 2009, payroll made up 82.5% of total compensation. By 2013, however, this had dropped to 78.7%.

The declining value of payroll as a component of total compensation can also be seen in the gradual changes in the average wage per employee. This calculation takes into account only the labor component of compensation, excluding benefits. The average wage per civil service employee decreased by 3.1% after adjusting for inflation, from $109,368 in FY 2012 to $105,927 in FY 2013.[16] Between FY 2009 and FY 2013, the average wage per civil service employed dropped from $116,000 to $105,927, or a decrease of 8.7%.[17]

[11] All dollar value comparisons in this section are adjusted for inflation.

[12] Total nominal compensation decreased by 0.9% ($2.1 million) between FY 2012 and FY 2013.

[13] Total nominal compensation *increased* by 4.9% ($10.4 million) between FY 2009 and FY 2013.

[14] Total nominal payroll decreased by 1.6% ($2.9 million) between FY 2012 and FY 2013.

[15] Total nominal payroll decreased by 0.1% ($0.1 million) between FY 2009 and FY 2013.

[16] The average wage per employee in nominal terms decreased 1.9% ($2,038) between FY 2012 and FY 2013.

[17] The average wage per employee in nominal terms decreased 0.9% ($962) between FY 2009 and FY 2013.

C.4. NASA GLENN EXPENDITURES, FY 2013

In FY 2013, NASA Glenn allocated its spending of $395.9 million to vendors in 48 states, Washington, D.C., Puerto Rico, and eleven foreign countries. Compared to its total expenditures of $434.7 million in FY 2012, NASA Glenn reduced its expenditures by 8.9% in FY 2013 ($38.8 million in nominal dollars). Total expenditures decreased by 25.4% ($135million) between FY 2009 and FY 2013.

When adjusted for inflation to 2013 dollars, the drop in expenditures is more telling.[18] Between FY 2012 and FY 2013, expenditures dropped by 10.2% ($45.1 million). When compared to FY 2009, expenditures for FY 2013 dropped by nearly a third, or 31.3%, a reduction of $180 million in constant 2013 dollars.

Figure 2 shows the geographic distribution of NASA Glenn's spending in FY 2013. Ohio was the largest beneficiary of expenditures, receiving $275 million of NASA Glenn's total expenditures. Despite a $15.3 million decrease (in nominal dollars) compared to FY 2012, the share of NASA Glenn's expenditures in Ohio increased from 66.7% in FY 2012 to 69.4% in FY 2013.

Of NASA Glenn's total expenditures in Ohio, Northeast Ohio received $223.8 million, which accounted for 81.5% of Ohio spending in FY 2013. Northeast Ohio also accounted for 56.5% of NASA Glenn's total spending in FY 2013. Cuyahoga County dominated NASA Glenn spending in Northeast Ohio, accounting for 98.3% of said spending. Additionally, Cuyahoga County represented 80.1% of spending in Ohio and 55.6% of total NASA Glenn spending in FY 2013

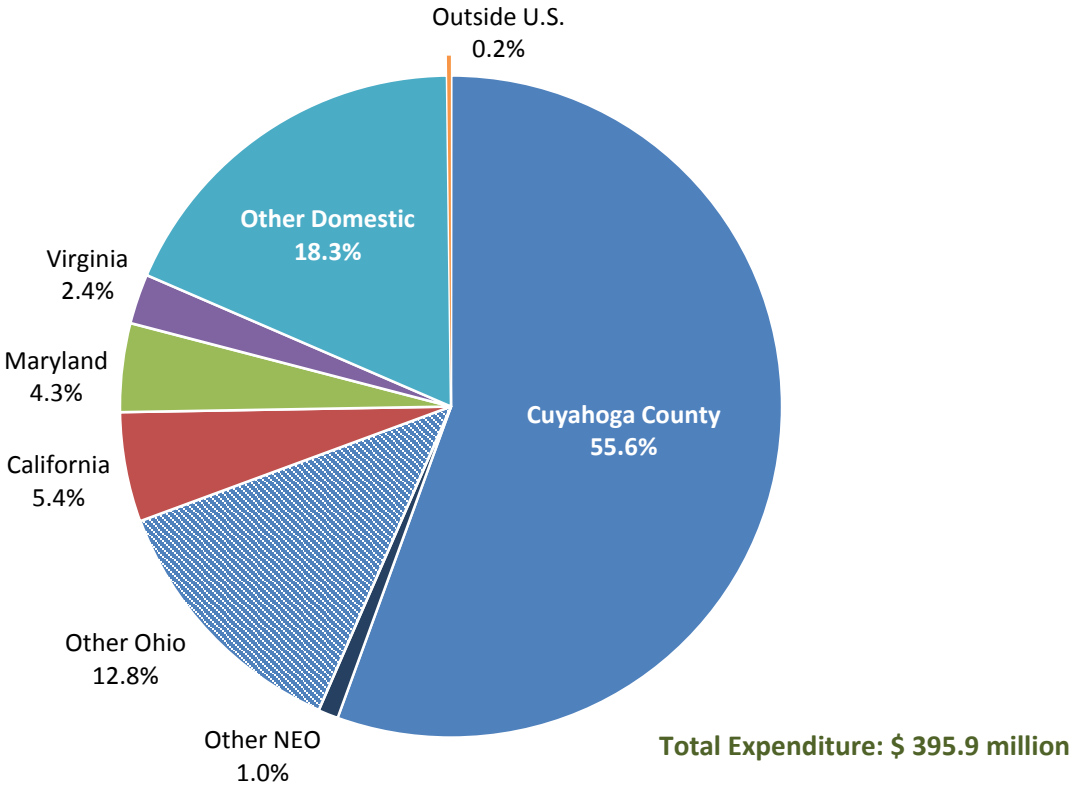
In addition to Ohio, three states (California, Maryland, and Virginia) each received over $9 million or at least 2.4% of NASA Glenn's total expenditures during FY 2013. California received $21.2 million (5.4%), Maryland $17.1 million (4.3%), and Virginia $9.6 million (2.4%), making them the second- , third-, and fourth-largest beneficiaries of NASA Glenn spending. Though posting the highest spending amounts, each of these states saw nominal declines in spending when compared to FY 2012's $3.1 million, $4.3 million and $0.9 million, respectively.

Aside from these states, Colorado saw the largest nominal dollar decline in expenditures at $3.9 million. Other states with large declines included Tennessee ($2.4 million) and Oklahoma ($2.3 million). Oklahoma also represented, after Hawaii (-95.3%), the highest percent decline in spending with a drop of 94.7% from FY 2012. The largest beneficiary of new spending in FY 2013 was New York, which saw an increase of $1.5 million in spending when compared to FY 2012. (See Appendix Table A.1. for more information.)

In FY 2013, NASA Glenn increased its expenditures in foreign countries by 89% compared to FY 2012, to $0.8 million. Even so, foreign countries received only 0.2% of NASA Glenn's total spending in FY 2013. The largest beneficiaries were Canada with $0.4 million and the United Kingdom with $0.2 million. (See Appendix Table A.1. for more information.)

[18] Inflation was adjusted using CPI-U for the United States

Figure 2. NASA Glenn Spending in Selected Regions, FY 2013



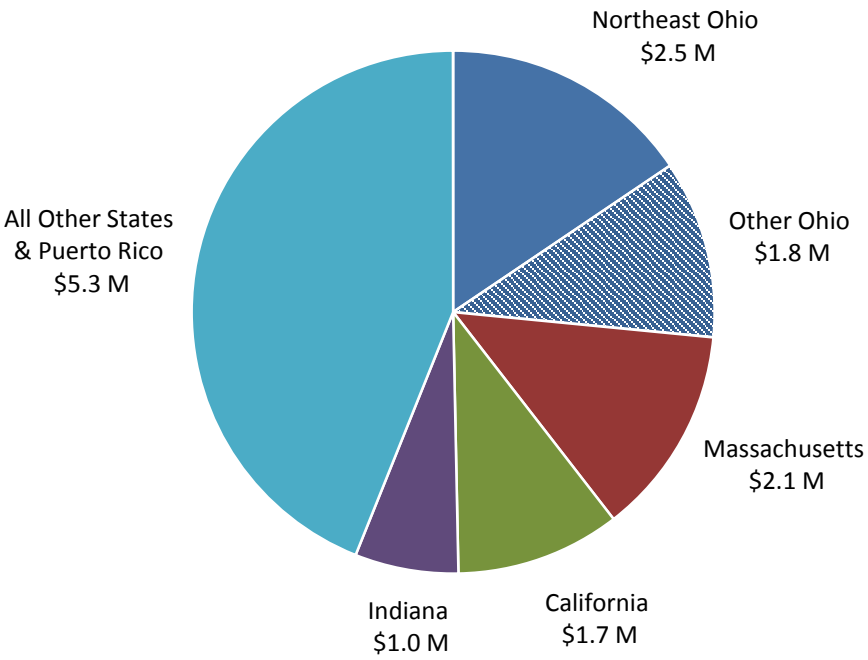
C.5. NASA Glenn Awards to Academic and Other Institutions

NASA Glenn Research Center awards funding to colleges, universities, and other nonprofit institutions in the form of R&D contracts and grants for assisting NASA in their R&D activities. The amount of NASA Glenn's funding to academic and major institutions is driven by NASA Glenn's goals and mission for each year.

In FY 2013, NASA Glenn awarded $16.2 million to colleges and universities in 32 states and Puerto Rico. Compared to FY 2012, this represented a reduction of academic grants from NASA Glenn of $6.1 million (-27.4% in nominal dollars).

Figure 3 shows the distribution of funding awarded to colleges and universities with emphasis on select states. Universities in four states—Ohio, Massachusetts, California, and Indiana—received over $1 million in funding from NASA Glenn in FY 2013. The academic funding awarded in these four states collectively accounted for 56.1% of the total grants in FY 2013. (See Appendix Table A.2. for more information.)

Figure 3. NASA Glenn Awards to Colleges and Universities, FY 2013



Total Academic Awards: $16.2 million

Notes:
Figures in nominal dollars
"Other Ohio" refers to colleges and universities located outside the 7-county definition of Northeast Ohio used in this report.

Academic institutions in Ohio received $4.3 million, which accounted for the largest share (26.5%) of NASA Glenn's academic awards in FY 2013. NASA Glenn's academic awards to Ohio decreased by 12.5% (-$0.6 million) between FY 2012 and FY 2013.

Within the state of Ohio, academic institutions in Northeast Ohio received $2.5 million in FY 2013. Northeast Ohio academic institutions accounted for both 15.5% of NASA Glenn's total academic awards and 58.6% of all academic grants given in Ohio. NASA Glenn slightly reduced its awards to the universities and academic institutions in Northeast Ohio by 6.9% (-$0.2 million) compared to FY 2012. NASA Glenn's funding to Ohio academic institutions located outside of Northeast Ohio's seven counties decreased by 19.3% (-$0.4 million) compared to FY 2012.

In FY 2013, the state of Massachusetts received $2.1 million, California received $1.7 million, and Indiana received $1 million in academic grants from NASA Glenn. (See Appendix Table A.2. for more details/information.)

Table 4 shows the distribution of NASA Glenn awards to colleges and universities in Ohio from FY 2009 to FY 2013 (inflated to 2013 dollars). Total academic grants awarded in Ohio decreased by 50%, from $8.6 million in FY 2009 to $4.3 million in FY 2013. Between FY 2012 and FY 2013, NASA Glenn reduced its academic funding to Ohio universities and colleges by 14% or $0.7 million (adjusted to 2013 dollars).

The University of Akron and University of Toledo each received more than $1.5 million from NASA Glenn in FY 2013. Though previously awarded the highest share of funding from FY 2009 through FY 2012, in FY 2013 the University of Toledo fell behind the University of Akron. The University of Akron, with funding in the amount of $1.8 million, accounted for 42.7% of total awards to colleges and universities in Ohio in FY 2013. Academic awards to the University of Akron increased by 20.1% ($0.3 million) between FY 2012 and FY 2013. On the other hand, NASA Glenn's academic funding to the University of Toledo increased by 1.9% ($30,000) from FY 2012 to FY 2013. University of Toledo educational grants represented 37.0% of total awards to colleges and universities in Ohio.

In FY 2013, Cleveland State University received $0.4 million, Case Western Reserve University received $0.3 million, and Ohio University received $0.1 million.

Table 4. NASA Glenn Educational Grants in Ohio by Academic Institution, FY 2009-FY 2013

Ohio Colleges & Universities	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2013 Share
University of Akron	$1,328,771	$676,645	$1,425,319	$1,531,900	$1,840,473	42.7%
University of Toledo	$2,759,973	$2,966,589	$2,110,057	$1,565,597	$1,595,279	37.0%
Cleveland State University	$776,521	$1,094,524	$731,157	$541,026	$376,577	8.7%
Case Western Reserve University	$867,370	$891,344	$828,273	$688,366	$302,089	7.0%
Ohio University	$74,429	$207,984	$187,583	$174,942	$91,344	2.1%
Ohio State University	$2,220,464	$1,553,130	$547,331	$380,894	$56,755	1.3%
University of Cincinnati	$527,217	$289,552	$180,821	$130,933	$41,710	1.0%
Kent State University		$374	$19,161		$5,625	0.1%
Wright State University	$35,169	$18,104	$33,956			
University of Dayton	$52,267					
Bowling Green State University	$30,675					
Cuyahoga Community College	$10,903					
TOTAL	**$8,683,759**	**$7,698,246**	**$6,063,658**	**$5,013,659**	**$4,309,854**	**100.0%**

Notes:
Table is sorted by FY 2013 column.
Data inflated to 2013 dollars.

C.6. NASA Glenn Revenues

NASA Glenn's total revenue in FY 2013 was $655.1 million. During the last five years, NASA Glenn's total revenue was lowest in FY 2013; with the exception of an increase in FY 2011, revenue has declined steadily since FY 2009. FY 2013 continued this trend with revenues decreasing by $32.6 million (-4.7%) from the previous year. Overall, NASA Glenn's revenue has decreased by $108.6 million (-14.2%) from FY 2009 to FY 2013 (in nominal dollars).

Table 5 shows NASA Glenn's revenue by source from FY 2009 to FY 2013. NASA Glenn's revenue consists of two sources: NASA direct authority and reimbursable commitments. The share of revenue from NASA's direct authority accounted for between 94% and 96% each year from FY 2009 to FY 2012, but dropped to less than 93% in FY 2013. In FY 2013, NASA Glenn received $608.6 million of revenue directly from NASA and an additional $46.5 million from reimbursable commitments.

As shown in Table 5 below, the growth in reimbursable funding is substantial—more than 42% growth from the FY 2009 level and reflects a growing diversity of non-NASA customers doing business with NASA Glenn in recent years. In the past year alone, Glenn's revenues from reimbursable commitments have increased by 15% ($6.1 million in nominal dollars) from FY 2012 to FY 2013. This increase is attributable to increased commercial investments in NASA Glenn, which over the past five years have more than doubled, with 29.6% growth between FY 2012 and FY 2013.

Nonetheless, federal sources remain the largest source of revenue for reimbursable commitments, accounting for 64% or $29.8 million. From FY 2012 to FY 2013, reimbursable commitments from the Department of Defense showed a 382% increase, driven largely by the US Air Force, which had a $7.8 million (780%) increase. Reimbursable commitments from the US Army also showed a large percentage increase of 418%, but with a smaller nominal increase ($713 thousand) comparatively. Despite this large increase, the Department of Defense accounted for 22.4% of total reimbursable commitments, with other federal agencies (41.8%) and domestic and non-federal entities (35.8%) accounting for the balance.

Table 5. NASA Glenn Revenues, FY 2009-FY 2013

Revenue Source	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
NASA Direct Authority	$731,026	$705,550	$696,917	$647,256	$608,600
Reimbursable Commitments	$32,606	$30,682	$41,680	$40,402	$46,457
Total FY Authority	$763,632	$736,232	$738,597	$687,657	$655,057
Revenue from NASA	95.7%	95.8%	94.4%	94.1%	92.9%

Note: Data in thousands of nominal dollars.

C.7. Taxes Paid by NASA Glenn Employees

Income taxes paid directly to state and local governments by NASA Glenn employees play an important role in the regional economies of Northeast Ohio and the state of Ohio. NASA Glenn is located in the cities of Brook Park, Fairview Park, and Cleveland, which affects the distribution of income tax paid by Glenn employees.

Table 6 shows the amount of income taxes withheld from the paychecks of NASA Glenn employees and sent directly to state and local governments. These taxes exclude those paid by Glenn employees to local governments based on their place of residence. In FY 2013, the total amount of income tax paid by NASA Glenn's employees was $9.45 million. This represented a decrease of 2.8% from FY 2012, a drop of nearly $400,000 (in nominal dollars). Compared to FY 2009, NASA Glenn employees paid $15,253 more in income taxes in FY 2013 (in nominal dollars).

The state of Ohio and the city of Brook Park were the two largest beneficiaries of the income taxes paid by NASA Glenn's employees. Together, they accounted for 99.6% of the total state and local income taxes paid in FY 2013. The state of Ohio's share of income tax in FY 2013 was 64.5% ($6.1 million). Over the past five years, NASA Glenn employees paid annually an average of more than $6.2 million in income taxes to the state of Ohio. The city of Brook Park received $3.3 million in income tax from NASA Glenn employees in FY 2013, a slight decrease (-1.6%) compared to FY 2012.

NASA Glenn employees paid $28,048 in income tax to the city of Fairview Park in FY 2013. This represented a 92.7% decrease in income tax paid by NASA Glenn workers to the city of Fairview Park between FY 2009 and FY 2013. This shift in taxes occurred due to the relocation of civil servants from facilities in Fairview Park to the main campus in 2010. At the same time, income tax paid to the city of Cleveland remained very low, although the total has increased between FY 2009 and FY 2013, peaking in FY 2012 at $14,205. In FY 2013, NASA Glenn employees paid $13,492 in income taxes to the city of Cleveland, a 5.0% decrease compared to FY 2012.

Table 6. Income Taxes Paid by NASA Glenn Employees

Year	City of Brook Park	City of Cleveland	City of Fairview Park	State of Ohio	Total
2009	$2,941,876	$9,174	$385,752	$6,098,786	**$9,435,588**
2010	$3,264,189	$11,465	$160,915	$6,346,527	**$9,783,096**
2011	$3,421,825	$12,755	$26,097	$6,384,735	**$9,845,412**
2012	$3,370,391	$14,205	$26,008	$6,309,804	**$9,720,408**
2013	$3,317,434	$13,492	$28,048	$6,091,867	**$9,450,841**

Note: Data in nominal dollars.

D. ECONOMIC IMPACT OF NASA GLENN

This section discusses the methodology and results of research on the economic impact of NASA Glenn on Northeast Ohio and the state of Ohio in FY 2013[19]. Total impact is measured in terms of output (sales); employment; value added; household earnings; and taxes contributed to local, state, and federal governments.

Each of these categories is estimated as the sum of three components: direct impact, indirect impact, and induced impact.[20] NASA Glenn's total impact on Northeast Ohio and the state of Ohio are estimated separately.

[19] For this analysis, Northeast Ohio is limited to seven counties: Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit.

[20] The change in final demand is the direct economic impact created by NASA Glenn on Northeast Ohio and Ohio.

D.1. METHODOLOGY

The estimation of NASA Glenn's economic impact in this study assumes that NASA Glenn established its operations in the region at the beginning of FY 2013 and generated a demand for its operation by purchasing goods and services from the supply industries.

This new demand is called "change in final demand," which represents the direct impact of NASA Glenn spending. [21] The increase in demand from NASA's expenditures (i.e. change in final demand) in the region generates an economic impact on Northeast Ohio and Ohio. The effects throughout the Northeast Ohio and Ohio economies are assessed using an input-output model that reflects the buy-sell relationships among all industry sectors.

In order for NASA Glenn to engage in research and development, it needs to buy supplies (goods and services) as intermediate inputs. Other purchases in the economy occur from income received by NASA Glenn employees, who buy goods and services for their households. These activities lead to the other components of economic impact: indirect and induced.
Indirect impact measures the value of labor, capital, and other inputs of production needed to produce the goods and services required by NASA Glenn as supplies for its operation. Induced impact measures the change in spending by local households due to increased earnings by Glenn employees and employees in local industries who produce goods and services for NASA Glenn and its suppliers.

For the calculation of direct value added impact, we treated NASA Glenn as any other research and development institution, assuming that NASA Glenn's intermediate expenditure pattern is the same as that of any other research institution in the target area.

Economic impact analysis takes into account inter-industry buy-sell relationships within the respective economy (NEO or Ohio). These relationships largely determine how the economy responds to changes in economic activity. Input-output (I-O) models estimate inter-industry relationships in a county, region, state, or country level by measuring the distribution of inputs purchased and outputs sold by each industry, the government sector, and the household sector. Thus, by using I-O models, it is possible to estimate how the impact of one additional dollar or one additional job required for NASA Glenn operation ripples through the target economies, creating additional expenditures and jobs. The economic multiplier measures the extent of the ripple effect that an initial expenditure has on the regional economy. [22]

This study utilizes regional I-O multipliers from the IMPLAN Professional model. [23]

[21] Change in final demand or direct impact, is defined as the total purchases of goods and services for NASA Glenn's overall operations.

[22] For example, suppose that Company "A" reports sales of $1 million. From the revenues, the company pays its suppliers and workers, covers production costs, and takes a profit. Once the suppliers and employees receive their payments, they will spend a portion of their money in the local economy purchasing goods and services, while another portion of the monies will be spent outside the local economy (leakage). By evaluating the chain of local purchases that result from the initial infusion of $1 million, it is possible to estimate a regional economic multiplier.

[23] IMPLAN (IMpact analysis for PLANning) was originally developed by two federal agencies, the Department of Agriculture and the Department of the Interior, to assist in land and resource management planning. The

Specifically, SAM multipliers are used to estimate the ripple effect that an initial expenditure made by NASA Glenn has on a local economy.[24] For this study, we used the method called "bill of goods" and applied it to industry change. We matched each category of NASA Glenn's expenditures to the industry from which it buys products. This technique enables the research to match goods that NASA Glenn bought to goods and services produced by different industries in the targeted region.

Three factors need to be addressed when estimating economic impact: (1) purchases from companies located outside of the study's region need to be excluded, (2) adjustment of total payroll accounting for the commuting pattern of NASA Glenn employees who live outside the study area, and (3) the share of revenues received from local sources needs to be considered. For this analysis, NASA Glenn's economic impact on the Northeast Ohio economy is generated only by purchases of goods produced from companies located in Northeast Ohio. Following the same methodology, the economic impact on the state of Ohio is generated by NASA Glenn purchases of goods and services produced from companies located in Ohio. Therefore, when estimating the impact on Northeast Ohio, goods and services purchased from businesses and other entities located outside of the seven-county region were excluded from the model; all goods and services purchased from businesses and entities located outside of the state were excluded when estimating the impact on the state of Ohio. The local spending of employees residing outside of the regions was included via adjustment of total payroll by commuting pattern. Specifically, IMPLAN takes into account the difference between the average regional share of commuting employees and the studied institution's share of employees living outside of the region. The model adjusts the total payroll by this difference, assuming that the commuting employees still spend part of their income in the area where they work. Meanwhile, all of NASA Glenn's revenues were received from non-local sources (federal sources) and, therefore, no further adjustments were required.

The economic impact is measured in terms of five variables: employment, labor income, value added, output, and taxes:

- Employment impact measures the number of additional jobs created in the region as a result of NASA Glenn expenditures.
- Labor income impact measures the additional labor earnings created in the region due to NASA Glenn expenditures.
- Value added impact measures the additional value added output created in the region as a result of NASA Glenn expenditures. Value added is calculated as output less the value of intermediary goods.[25]
- Output impact measures the additional value of all goods and services produced in the region as a result of NASA Glenn expenditures.
- Tax impact measures the additional federal and state and local tax revenues collected in the region as a result of NASA Glenn expenditures.

The employment, labor income, value added, and output impacts are each a summation of

Minnesota IMPLAN Group, Inc. later commercialized the model as a software package.

[24] IMPLAN type SAM (Social Accounting Matrices) multipliers are used in this study. SAM multipliers are based on information in a social account matrix that considers commuting, institutional savings, inter-institutional transfers, and social security and income tax leakages.

[25] Intermediary goods and services—such as energy, materials, and purchased services—are purchased for the production of other goods and services rather than for final consumption.

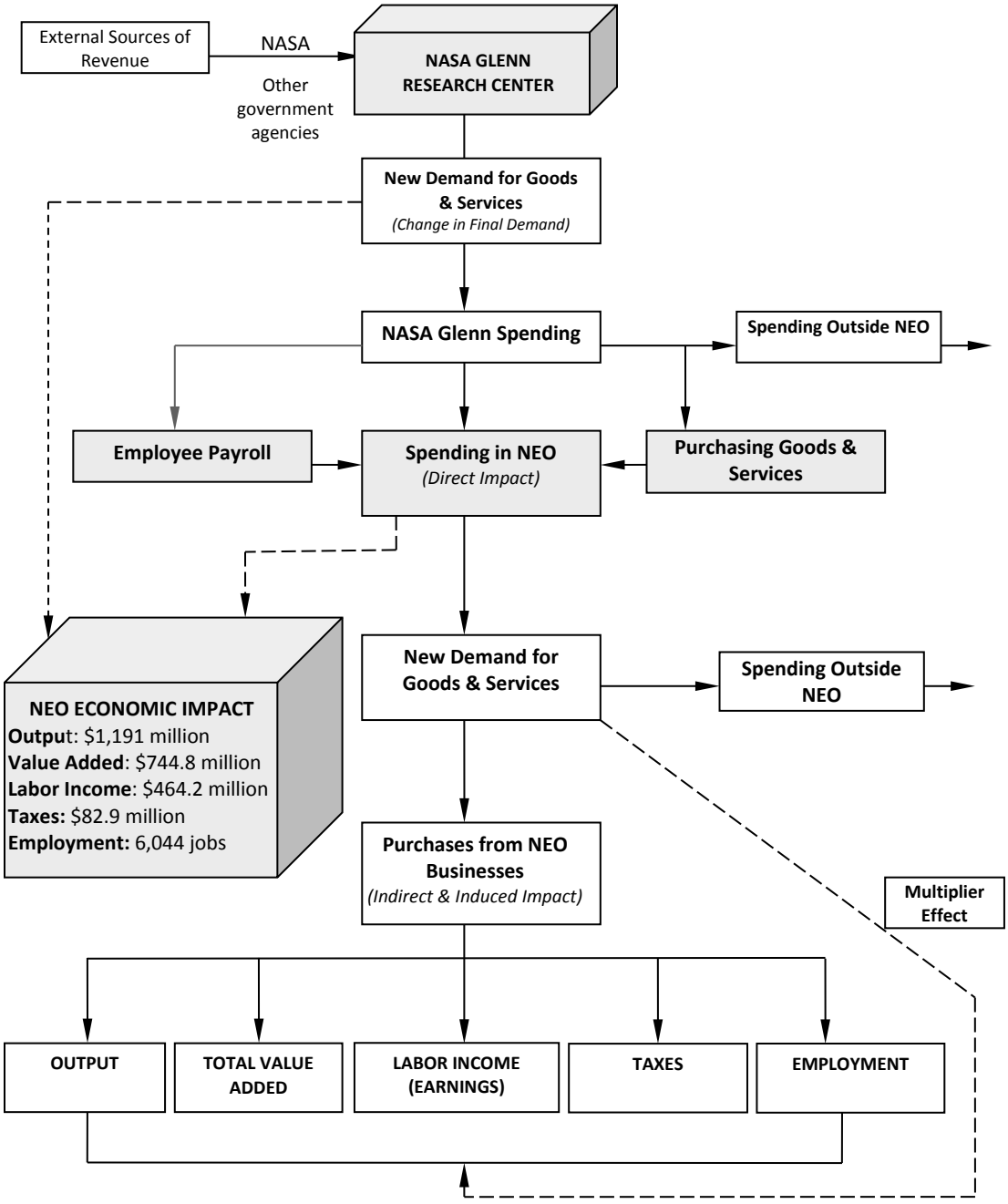
three components: direct impact, indirect impact, and induced impact. [26]

Figure 4 illustrates the process by which NASA Glenn impacted the local economy through its spending in Northeast Ohio in FY 2013.

Through its attraction of federal dollars, NASA Glenn created new demand for goods and services (change in final demand/direct impact). Some of this demand was generated for goods and services provided by vendors outside Northeast Ohio and Ohio, resulting in dollars leaking from the regional and state economies. However, the majority of goods and services were purchased locally.

[26] The summation of direct, indirect, and induced impacts across industries in the impact tables (Tables 7-14) may reflect rounding discrepancies created by multiple iterations of IMPLAN modeling. According to IMPLAN, the discrepancies of up to 3% are due to rounding during multiple iterations of data calculations in the model.

Figure 4. Economic Impact of NASA Glenn Research Center on Northeast Ohio, FY 2013



D.2. Economic Impact on Northeast Ohio, FY 2013

This section describes the economic impact that NASA Glenn had on Northeast Ohio's economy in FY 2013. The analysis includes a detailed overview of the changes in output (sales), employment, labor income (earnings), value added, and taxes generated by NASA Glenn's activities in Northeast Ohio.

D.2.1. Output Impact on Northeast Ohio, FY 2013

To calculate an output income, NASA Glenn's expenditures were divided into two groups of spending: (1) goods and services purchased from companies and institutions located in Northeast Ohio and (2) spending for goods and services from businesses and other entities located outside Northeast Ohio. The first group of spending creates an economic impact on the economy of Northeast Ohio. The second group is considered leakage from this region; therefore, these expenditures are not included in calculating the output impact on Northeast Ohio. Local spending is then categorized by products produced by different industries in the local economy, based on an IMPLAN classification system of industries. The spending is coded across 440 sectors. IMPLAN industry sectors are similar to the description of industries used in the North American Industry Classification System (NAICS) but do not fully correspond to the NAICS system. Table A.3., found in Appendix A, provides detailed NASA Glenn expenditures in Northeast Ohio by industry.

Over 40% of NASA Glenn spending in Northeast Ohio was for employee compensation. NASA Glenn's largest expenditures on goods and services in Northeast Ohio in FY 2013 were made on scientific research and development services (21%), including equipment, supplies and materials, grants, and professional services. The spending that takes place in Ohio and Northeast Ohio produces significant economic impact on the respective economies.

Table 7 presents the total output impact of NASA Glenn, comprised of direct impacts, indirect impacts, and induced impacts. NASA Glenn's total expenditures for operations represent the direct output impact for Northeast Ohio. This impact includes the regional margin of purchases from the retail industry. Indirect impact is estimated as all direct purchases of goods and services made from industries in Northeast Ohio and the contributions of individual industries that supply the producers of the goods and services consumed by NASA Glenn. Lastly, induced impact is estimated from the spending of employees of Glenn and its suppliers.

Table 7. Output Impact in Northeast Ohio, FY 2013 (in 2014 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	$0	$66,243	$178,918	$245,161
Mining	$0	$919,962	$638,547	$1,558,509
Utilities	$0	$16,207,709	$5,605,816	$21,813,525
Construction	$0	$30,806,867	$1,986,645	$32,793,513
Manufacturing	$0	$4,982,755	$6,856,918	$11,839,672
Wholesale Trade	$0	$2,227,462	$14,865,167	$17,092,629
Retail Trade	$0	$2,098,424	$27,838,768	$29,937,192
Transportation & Warehousing	$0	$2,845,387	$5,775,019	$8,620,405
Information	$0	$4,675,466	$9,543,838	$14,219,305
Finance & Insurance	$0	$8,490,739	$31,975,206	$40,465,944
Real Estate & Rental	$0	$5,818,928	$53,854,163	$59,673,091
Professional- Scientific & Tech Services	$0	$143,214,805	$11,576,888	$154,791,694
Management of Companies	$0	$1,723,205	$2,404,519	$4,127,724
Administrative & Waste Services	$0	$62,097,202	$7,361,017	$69,458,219
Educational Services	$0	$2,633,442	$5,356,216	$7,989,658
Health & Social Services	$0	$12,012	$50,976,369	$50,988,381
Arts- Entertainment & Recreation	$0	$938,972	$4,352,549	$5,291,521
Accommodation & Food Services	$0	$2,050,064	$15,012,124	$17,062,188
Other Services	$0	$2,152,450	$10,967,072	$13,119,523
Government & non-NAICs	$625,205,155	$940,105	$4,118,180	$630,263,440
TOTAL OUTPUT	$625,205,155	$294,902,199	$271,243,939	**$1,191,351,293**

Notes: For output impact, the change in final demand or direct impact ($625,205,155) equals the total spending of NASA Glenn for goods and services in- and outside of Northeast Ohio, including wages and benefits ($619,961,444 in $2013), with minor discrepancies due to IMPLAN rounding errors and inflation of results to 2014 dollars.

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The total output impact of NASA Glenn on Northeast Ohio was $1.191 billion in FY 2013. NASA Glenn's $625 million worth of expenditures accounting for goods and services bought from Northeast Ohio resulted in an output (sales) change of $1.191 billion across all industry sectors (Table 7). For example, NASA Glenn's spending caused a $154.8 million increase in total sales by all professional, scientific, and technical services industries and a $51 million increase in sales (direct, indirect, and induced impacts) by the health and social services industry. Furthermore, if NASA Glenn did not exist in Northeast Ohio, the regional economy would suffer a $60 million decrease in output in the real estate and rental industry. Thus, the impact of NASA Glenn's presence in the area is represented as the increase in output of affected industries in comparison to the hypothetical absence of NASA Glenn in Northeast Ohio.

Of the total output impact, 52.5% ($625.2 million in 2014 dollars) is accounted for by NASA Glenn's direct spending, which constitutes the direct economic impact to Northeast Ohio. The remaining output impact of $566.1 million (47.5%) is due to the indirect and induced components as NASA Glenn purchases directly from companies and first-round suppliers ripple through the economy.

A detailed analysis of the IMPLAN model's results indicates that the $566.1 million change in output (sales) due to indirect and induced economic impacts can be divided into three broad categories: NASA Glenn-driven industries, consumer-driven industries, and other industries. NASA Glenn-driven industries are industries that increase sales, employment, and earnings primarily, but not exclusively, due to NASA Glenn's spending. Among these industries are utilities, construction, information, professional and scientific services, administrative and support services, and education. The increase in output due to indirect and induced economic impacts for these industries in FY 2013 was $301.1 million or 53.2% of NASA Glenn's overall indirect and induced impact on Northeast Ohio.

The consumer-driven industries are those that increase sales, employment, and earnings primarily due to spending by NASA Glenn employees and other workers who produce goods and services for NASA Glenn and their suppliers. These industries include retail, healthcare, real estate, other services, owner-occupied buildings, finance and insurance, and entertainment and food.[27] The increase in output due to indirect and induced economic impacts for these industries in FY 2013 was $216.5 million, or 38.2%, of the total impact.

Other industries are those that are driven by both NASA Glenn and consumer spending, but their impact is split between NASA Glenn and other businesses in the region. These industries include mining, manufacturing, agriculture, government enterprises, wholesale trade, and transportation and warehousing. The total increase in output due to indirect and induced economic impacts for these industries in FY 2013 was $48.5 million or 8.6% of the total impact.

[27] An *owner-occupied dwelling* is a special industry sector developed by the Bureau of Economic Analysis. It estimates what owner/occupants would pay in rent if they rented rather than owned their homes. This sector creates an industry out of owning a home. Its sole product (or output) is ownership, purchased entirely by personal consumption expenditures. Owner-occupied dwellings capture the expenses of home ownership such as repair and maintenance construction, various closing costs, and other expenditures related to the upkeep of the space in the same way expenses are captured for rental properties.

The output distributions for select NASA Glenn-driven industries and consumer-driven industries are shown in Figure 5 and Figure 6, respectively. Each of the industries presented in Figure 5 had additional sales of at least $15 million in FY 2013. Each of the industries presented in Figure 6 had additional sales of at least $8 million in FY 2013.

The scientific research and development industry generated the largest output impact; it increased by $83.7 million in FY 2013 due to NASA Glenn's operations (Figure 5). This amount is the summation of the indirect and induced impacts generated primarily, but not exclusively, by NASA Glenn's spending on research services. The increase of $83.7 million accounted for 27.8% of the $301.1 million increase in output for all NASA Glenn-driven industries. Other industries shown in Figure 5 can be interpreted similarly.

Figure 6 presents consumer-driven industries of the economy that saw large increases in sales. The imputed rental activity industry generated the largest output impact; it increased by $33.6 million in FY 2013 due to NASA Glenn's operations in Northeast Ohio. This amount is the summation of the indirect and induced impacts generated primarily by NASA Glenn employees and other workers for rental activities. The increase of $33.6 million accounted for 15.5% of the $216.5 million increase in output for all industries within the consumer-driven sector.

Figure 5. Increase in Sales for Select NASA Glenn-Driven Industries in Northeast Ohio, FY 2013

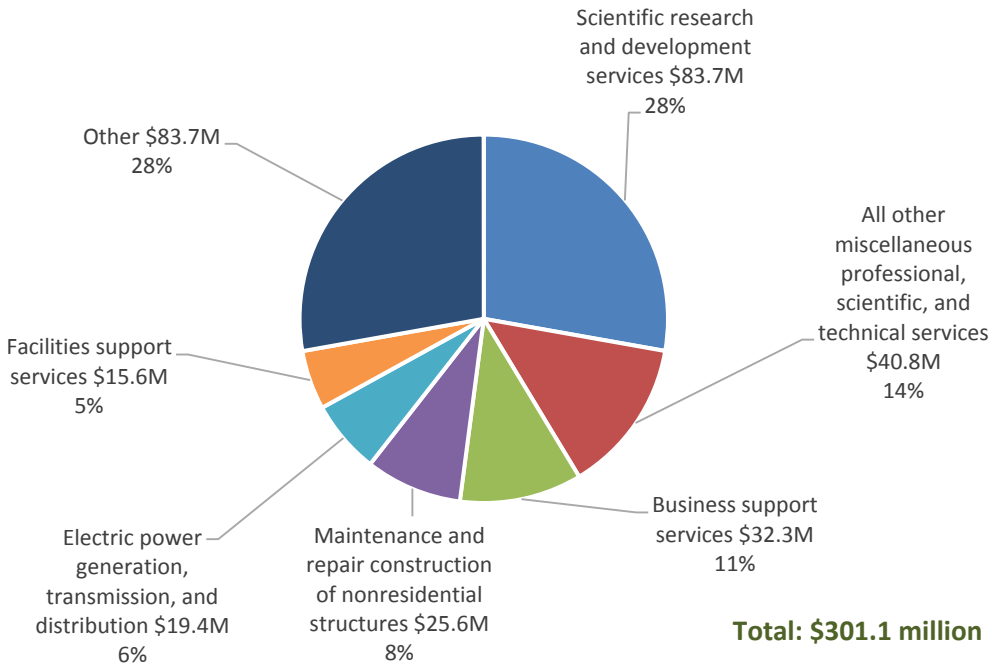
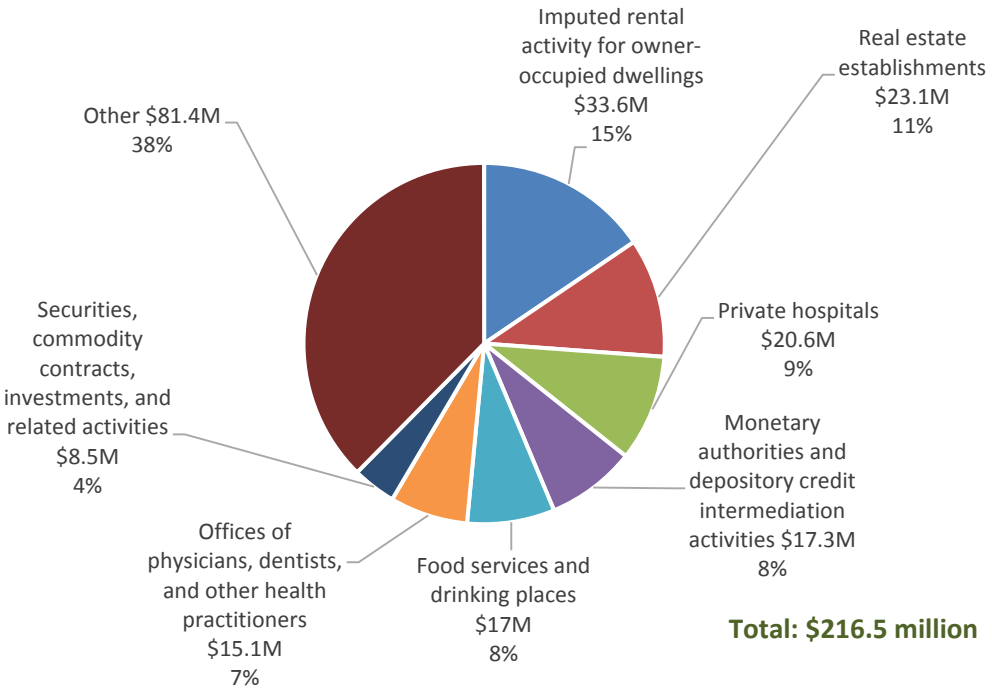


Figure 6. Increase in Sales for Select Consumer-Driven Industries in Northeast Ohio, FY 2013



D.2.2. Employment Impact on Northeast Ohio, FY 2013

NASA Glenn's operation in Northeast Ohio supported existing and created new jobs in addition to its own employment (change in final demand or direct impact). NASA Glenn's spending triggered increased employment in industries from which it purchased goods and services and their suppliers (indirect impact).

In addition, money spent by employees of NASA Glenn, employees of the businesses from which NASA Glenn buys goods and services, and employees of the companies in the supply chain generate indirect and induced employment effect on the regional economy. The total employment impact equals the sum of NASA Glenn's employment (direct impact), indirect impact, and induced impact. Table 8 shows the number of new and supported jobs by industry sector.

Table 8. Employment Impact in Northeast Ohio, FY 2013

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing, & Hunting	0	3	3	5
Mining	0	5	3	8
Utilities	0	19	6	25
Construction	0	238	14	251
Manufacturing	0	14	16	30
Wholesale Trade	0	11	69	80
Retail Trade	0	62	394	456
Transportation & Warehousing	0	17	40	57
Information	0	14	29	43
Finance & Insurance	0	33	131	164
Real Estate & Rental	0	33	129	162
Professional- Scientific & Tech Services	0	834	83	916
Management of Companies	0	7	10	18
Administrative & Waste Services	0	806	116	922
Educational Services	0	37	85	122
Health & Social Services	0	0	499	499
Arts- Entertainment & Recreation	0	12	72	84
Accommodation & Food Services	0	36	262	298
Other Services	0	26	179	204
Government & non-NAICs	1,664	7	28	1,700
TOTAL EMPLOYMENT	1,664	2,213	2,167	**6,044**

Notes: For employment impact, the change in final demand (direct impact) equals the number of employees working for NASA Glenn.

The total employment impact of NASA Glenn on the Northeast Ohio economy in FY 2013 was 6,044 jobs. Of these 6,044 jobs, 1,664 (27.5%) were directly employed at NASA Glenn. As a result of Glenn's direct spending on goods and services, an additional 2,213 jobs (36.6%) were supported and created in the region as indirect economic impact. The rest of the employment impact, 2,167 jobs (35.8%), was created as induced impact due to spending of NASA Glenn and suppliers' employees flowed through various industries of the regional economy.

Of the 4,380 jobs created in Northeast Ohio due to the indirect and induced impacts, 2,280 (52.1%) were in NASA Glenn-driven industries, 1,866 (42.6%) were in consumer-driven industries, and 234 (5.3%) fell under the category of other industries.[28] The job distribution for select NASA Glenn-driven industries is shown in Figure 7. The job distribution for select consumer-driven industries is shown in Figure 8. The industries presented in Figures 7 and 8 are the leading industries in terms of most increased employment (a minimum of 100 and 50 employees per industry, respectively).

The scientific research and development industry generated the highest number of additional jobs. Companies engaged in scientific R&D (professional, scientific, and technical services sector) saw an increase of 471 jobs in FY 2013 due to NASA Glenn's operation in Northeast Ohio (Figure 7). These jobs are the summation of the indirect and induced employment impacts generated primarily, but not exclusively, by NASA Glenn's spending on R&D contractors in Northeast Ohio. The 471 jobs accounted for 21% of the 2,280 jobs that were created in all industries within the NASA Glenn-driven industries. Other industries shown in Figure 7 can be interpreted similarly.
The food services and drinking places industry saw the largest increase among consumer-driven industries; the increase of 297 jobs in FY 2013 was due to NASA Glenn's spending that generates labor income in regional supply industries (Figure 8). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily by NASA Glenn employees and other workers buying food and going to restaurants in Northeast Ohio. The 297 jobs accounted for 16% of the 1,866 jobs that were created in all consumer-driven industries.

[28] NASA Glenn-driven industries include utilities, construction, information, education, professional and scientific services, and administrative and support services. Consumer-driven industries include retail, healthcare, real estate, other services, owner-occupied buildings, and finance and insurance.

Figure 7. Increase in Jobs for Select NASA Glenn-Driven Industries in Northeast Ohio, FY 2013

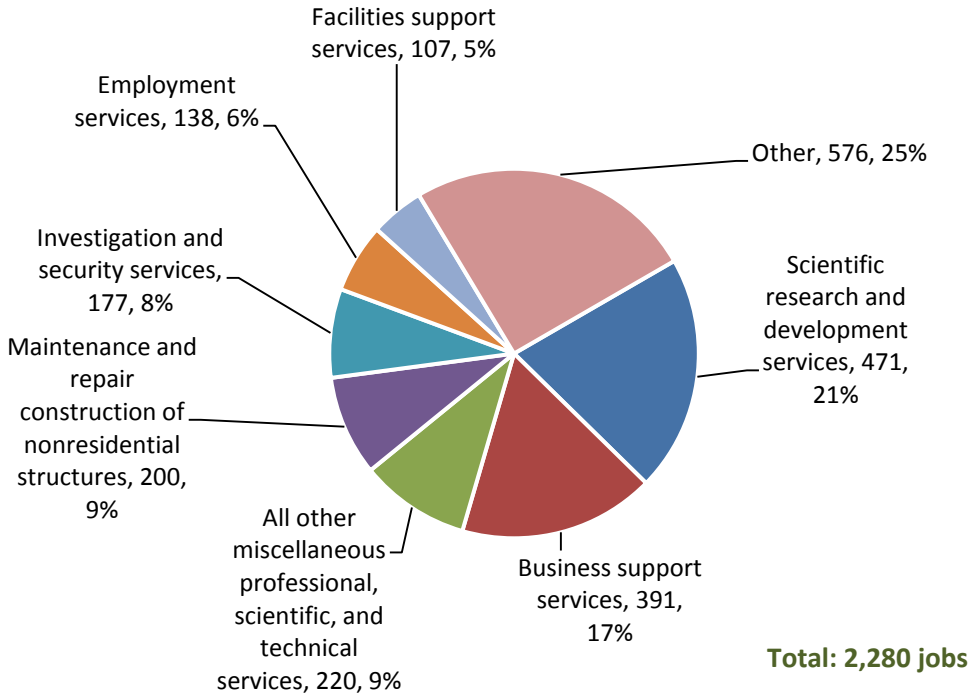
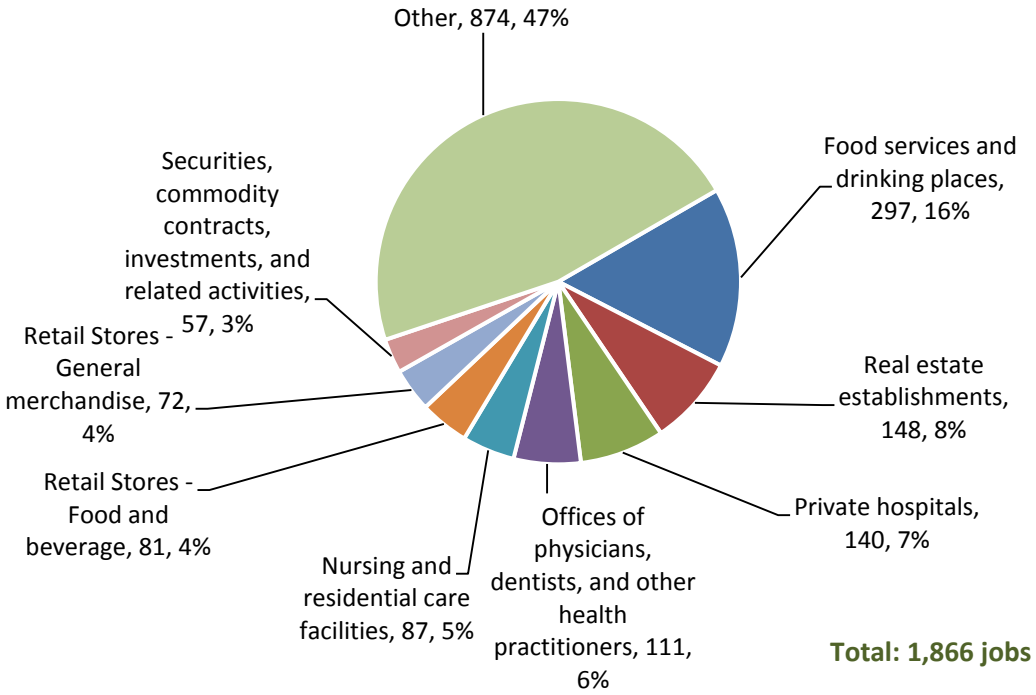


Figure 8. Increase in Jobs for Select Consumer-Driven Industries in Northeast Ohio, FY 2013



D.2.3. Labor Income Impact on Northeast Ohio, FY 2013

Labor income impact is the estimated total change in labor income paid to employees of local businesses due to spending by NASA Glenn for goods and services purchased in Northeast Ohio and the money paid to employees of NASA Glenn. The direct economic impact represents the total compensation NASA Glenn pays its employees.

Indirect impact is estimated by summing the money paid to people working for companies that provide products and services purchased by NASA Glenn and inputs to the producers of goods and services ultimately consumed by NASA Glenn.

Induced impact represents money paid to workers in all industries who are employed as a result of purchases by people whose income is affected by the demand for products and services created by NASA Glenn. The total earnings impact includes the wages and benefits received by NASA Glenn employees (change in final demand or the direct effect), indirect, and induced impacts. Table 9 shows the earnings impact by industry sector.

Table 9. Labor Income Impact in Northeast Ohio, FY 2013 (in 2014 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing, & Hunting	$0	$39,315	$116,206	$155,521
Mining	$0	$232,289	$162,527	$394,816
Utilities	$0	$2,525,869	$821,591	$3,347,460
Construction	$0	$13,518,044	$820,706	$14,338,750
Manufacturing	$0	$1,058,676	$1,045,580	$2,104,255
Wholesale Trade	$0	$926,903	$6,161,980	$7,088,883
Retail Trade	$0	$1,505,245	$13,050,997	$14,556,242
Transportation & Warehousing	$0	$1,078,121	$2,304,528	$3,382,649
Information	$0	$974,774	$1,897,291	$2,872,064
Finance & Insurance	$0	$2,125,072	$8,254,210	$10,379,282
Real Estate & Rental	$0	$1,026,217	$3,304,248	$4,330,465
Professional- Scientific & Tech Services	$0	$73,537,636	$6,484,651	$80,022,288
Management of Companies	$0	$934,177	$1,303,528	$2,237,704
Administrative & Waste Services	$0	$37,324,249	$4,137,593	$41,461,842
Educational Services	$0	$1,595,598	$2,952,353	$4,547,951
Health & Social Services	$0	$5,886	$29,247,294	$29,253,179
Arts- Entertainment & Recreation	$0	$390,160	$1,923,253	$2,313,413
Accommodation & Food Services	$0	$790,435	$5,795,172	$6,585,607
Other Services	$0	$1,304,430	$6,668,586	$7,973,016
Government & non-NAICs	$224,093,222	$595,593	$2,157,706	$226,846,521
TOTAL LABOR INCOME	$224,093,222	$141,488,689	$98,609,998	**$464,191,909**

Notes: Labor income constitutes economic impact through households of NASA employees and those affected by NASA operations throughout the economy.

Total labor income in Northeast Ohio increased by $464.2 million as a result of NASA operation in FY 2013. Of the $464.2 million, $224.1 million (48.3%) constituted wages and benefits paid directly to NASA Glenn employees (i.e., change in final demand or direct effect measured is 2014 dollars). Of the total impact, $141.5 million (30.5%) represented indirect impact, or the money paid to employees of companies in Northeast Ohio that supply goods and services to NAGA Glenn. The remaining induced earnings were $98.6 million (21.2%); they occurred as the effects of NASA Glenn's spending rippled through the Northeast Ohio economy via labor income spending.

Of the $240.1 million increase in labor income generated across Northeast Ohio due to the indirect and induced impacts, $146.6 million (61.1%) was reported in NASA Glenn-driven industries, $75.4 million (31.4%) was generated in consumer-driven industries, and $18.1 million (7.6%) was reported in other industries.[29]

The labor income distribution for select NASA Glenn-driven industries is shown in Figure 9. The labor income distribution for select consumer-driven industries is shown in Figure 10. The select industries shown in Figures 9 and 10 each added over $4 million and $2.5 million, respectively.

In the NASA Glenn-driven industries, people who were engaged in business support services saw their labor income increase by $23.6 million in FY 2013 (Figure 9). These earnings are the summation of the indirect and induced impacts generated primarily, but not exclusively, by NASA Glenn using business support services in Northeast Ohio. The $23.6 million accounted for 16.1% of the $146.6 million increase in labor income reported by all the NASA Glenn-driven industries.

Private hospitals, part of the consumer-driven industries, saw their labor income increase by $10.6 million in FY 2013 (Figure 10). These earnings are the summation of the indirect and induced impacts generated by consumer spending for doctors' services. The $10.6 million accounted for 14.1% of the $75.4 million labor income increase that occurred in all consumer-driven industries.

[29] See section D.2.1. Output Impact on Northeast Ohio for definitions of Glenn-driven, consumer-driven, and other industries.

Figure 9. Increase in Labor Income for NASA Glenn-Driven Industries in Northeast Ohio, FY 2013

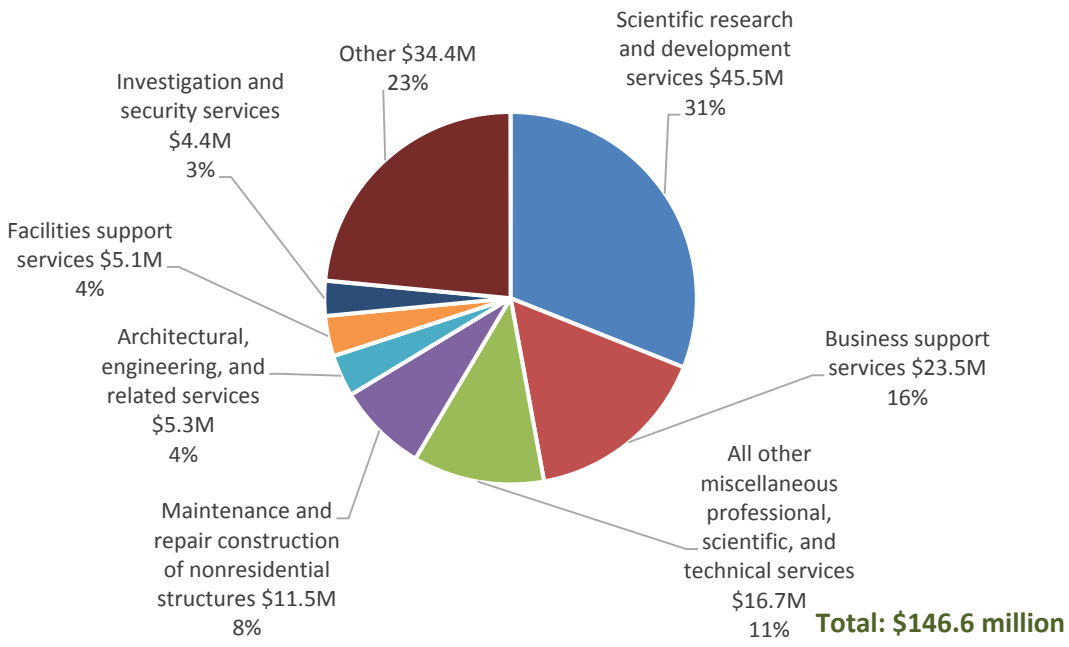
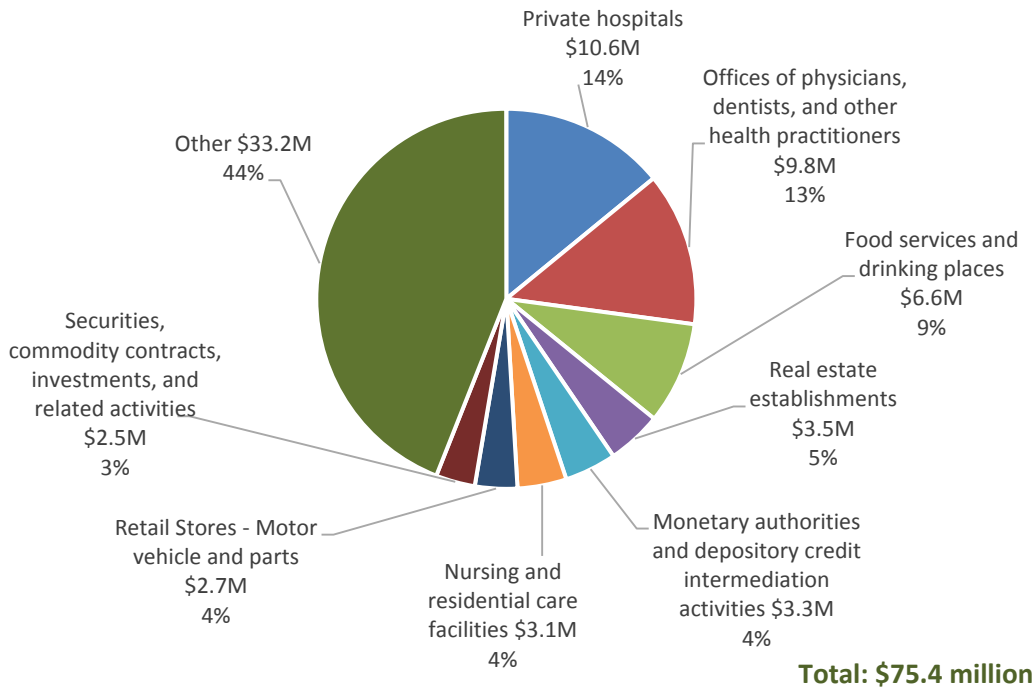


Figure 10. Increase in Labor Income for Consumer-Driven Industries in Northeast Ohio, FY 2013



D.2.4. Value Added Impact on Northeast Ohio, FY 2013

The total value added impact[30] in Northeast Ohio was $744.8 million,[31] which resulted from NASA Glenn's regional spending on goods and services. NASA Glenn's spending led to a $744.8 million increase in sales (direct, indirect, and induced impacts) by all industries, excluding intermediary goods and services. The total output less intermediate expenditures, $375.1 million in FY 2013, constituted the change in final demand (or direct impact) for value added. The sales from companies and other suppliers of goods and services to NASA Glenn, excluding the value of intermediary goods and services, represented the indirect value added impact.

Induced impact represents sales, excluding intermediary goods and services, in all industries that produced products for industries in which income was affected by the demand for products and services created by NASA Glenn. The total value added impact was found by adding the direct, indirect, and induced impacts. Table 10 shows the value added impact by industry sector.

[30] "Value added" measures the economic impact of all goods and services produced in Northeast Ohio because of the operation of NASA Glenn, excluding intermediary goods which are goods used in the production of other goods and not for final consumption.

[31] The total value added impact is significantly larger in this study compared to the last year due to the improved method of accounting for direct value added, which is calculated as total output less intermediate expenditures. In previous studies, we accounted only for a fraction of the direct value added, i.e. the total labor income expenditures of NASA Glenn.

Table 10. Value Added Impact in Northeast Ohio, FY 2013 (in 2014 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	$0	$29,189	$96,274	$125,463
Mining	$0	$197,738	$109,743	$307,481
Utilities	$0	$11,020,169	$3,343,046	$14,363,215
Construction	$0	$13,677,448	$899,234	$14,576,682
Manufacturing	$0	$1,840,065	$1,937,369	$3,777,434
Wholesale Trade	$0	$1,514,354	$10,067,312	$11,581,667
Retail Trade	$0	$2,539,963	$20,669,582	$23,209,545
Transportation & Warehousing	$0	$1,615,781	$3,183,037	$4,798,818
Information	$0	$2,146,437	$4,583,348	$6,729,785
Finance & Insurance	$0	$5,356,486	$18,603,920	$23,960,407
Real Estate & Rental	$0	$4,454,867	$40,678,430	$45,133,297
Professional- Scientific & Tech Services	$0	$97,923,039	$8,774,015	$106,697,054
Management of Companies	$0	$1,108,176	$1,546,322	$2,654,498
Administrative & Waste Services	$0	$45,837,326	$5,041,417	$50,878,743
Educational Services	$0	$1,684,693	$3,402,556	$5,087,249
Health & Social Services	$0	$9,227	$32,452,954	$32,462,181
Arts- Entertainment & Recreation	$0	$539,506	$2,559,566	$3,099,073
Accommodation & Food Services	$0	$1,108,014	$8,115,071	$9,223,085
Other Services	$0	$1,431,429	$6,900,258	$8,331,688
Government & non-NAICs*	$375,123,093	$552,948	$2,072,449	$377,748,490
TOTAL VALUE ADDED	$375,123,093	$194,586,858	$175,035,903	**$744,745,854**

Notes: For value added impact, the change in final demand or direct impact equals the total output less intermediate expenditures. For this study, we treated NASA Glenn as any other research and development institution, assuming that NASA Glenn's intermediate expenditure pattern is the same as that of any other research institution in the Northeast Ohio. For an average research institution in Northeast Ohio, the intermediate expenditures accounted for 40% of total output.

Total value added in Northeast Ohio increased by $744.8 million in FY 2013 as a result of NASA Glenn's spending on goods and services. Of this total amount, $375.1 million (50.4%) accounts for the change in final demand or direct impact, calculated as total output less intermediate expenditures. The large portion of the value added in the wages and salaries paid to NASA Glenn employees. Another $194.6 million (26.1%) represented the value of goods and services, less intermediary goods, of companies in Northeast Ohio that supply to NASA Glenn (i.e., indirect impact). The remaining value added impact (induced component) was estimated at $175 million (23.5%). It occurred as a result of NASA Glenn's spending rippling through the Northeast Ohio economy.

Of the $369.6 million increase in value added generated across Northeast Ohio due to the indirect ($194.6 million) and induced impacts ($175 million), $195.9 million (53%) was reported in NASA Glenn-driven industries, $145

(39.2%) was generated in consumer-driven industries, and $28.7 million (7.8%) was reported in other industries.[32]

The value added distribution for select NASA Glenn-driven industries is shown in Figure 11. The value added distribution for select consumer-driven industries is shown in Figure 12. Each of the select industries showed in Figures 11 and 12 added at least $11 million and almost $5 million each, respectively.

The scientific research and development services industry, the largest NASA Glenn-driven industries, saw a value added increase of $51 million in FY 2013 (Figure 11). This increase in value added is a result of the indirect and induced impacts' summation, generated primarily, but not exclusively, by NASA Glenn using miscellaneous business support services in Northeast Ohio. The $51 million accounted for 25.7% of the $198.3 million value added increase that was reported by all NASA Glenn-driven industries.

People working at the Imputed rental activity for owner-occupied dwellings industry saw their value added grow by $24.7 million in FY 2013 (Figure 12). This value added increase is a result of the summation of the indirect and induced impacts generated by consumer spending at real estate establishments. The $24.7 million accounted for 17% of the $145.4 million value added increase that occurred in all consumer-driven industries.

[32] See section D.2.1. Output Impact on Northeast Ohio for definitions of NASA Glenn-driven, consumer-driven, and other industries.

Figure 11. Increase in Value Added for NASA Glenn-Driven Industries in Northeast Ohio, FY 2013

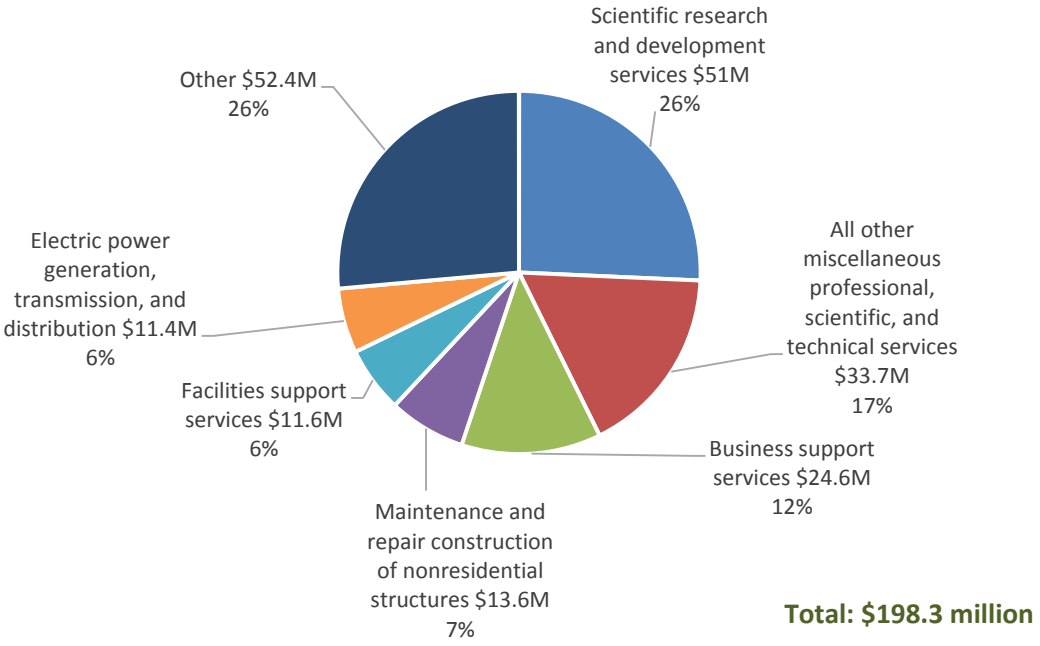
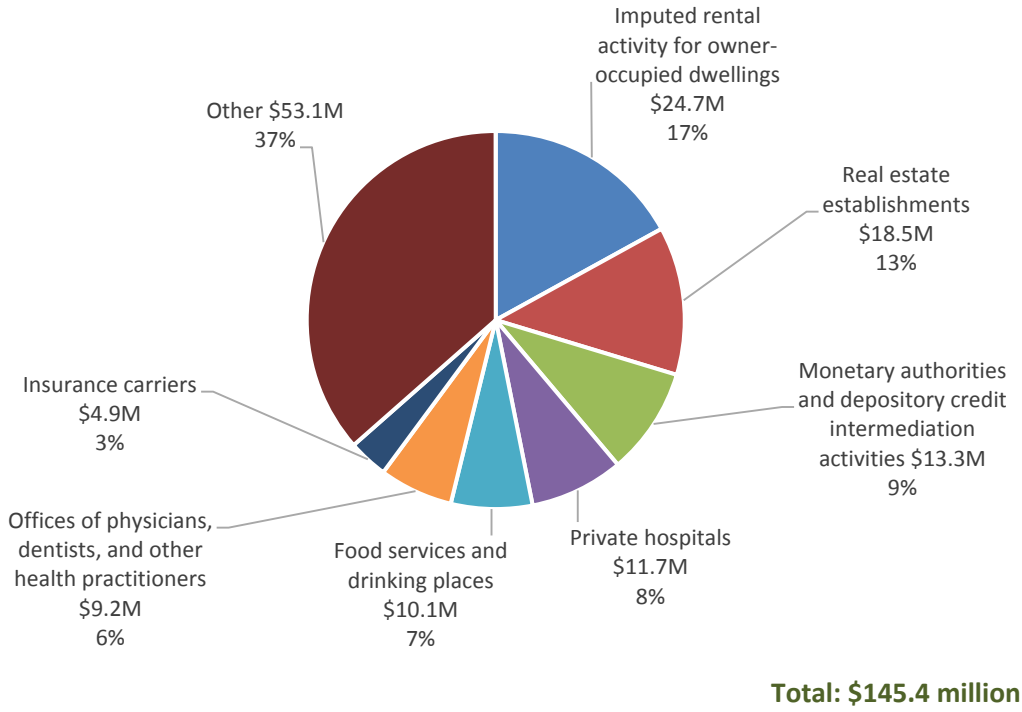


Figure 12. Increase in Value Added for Consumer-Driven Industries in Northeast Ohio, FY 2013



D.2.5. Tax Impact on Northeast Ohio, FY 2013

NASA Glenn's operation in Northeast Ohio generated a total of $82.9 million in tax revenues in FY 2013. Of that amount, the direct tax impact—the amount NASA Glenn's employees pay—was $9.5 million, $35.4 million was indirect tax impact, and $37.9 came from induced tax impact.[33]

D.2.6. FY 2013 Northeast Ohio Impact Summary

Economic activity conducted by NASA Glenn generated the following impact on Northeast Ohio (adjusted to 2014 dollars):

- Total Output Impact: $1,191.4 M
- Total Employment Impact: 6,044 jobs
- Total Labor Income Impact: $464.2 M
- Total Value Added Impact: $744.8 M
- Total Tax Impact: $82.9 M

The economic impact presented here reflects the benefits of NASA Glenn's overall expenditures of $625.2 million, including total expenditures of $225.7 million spent on purchases in Northeast Ohio in FY 2013 and expenditures on labor income paid to NEO employees and commuters at the amount of $218.8 million (in 2014 dollars).

Excluding expenditures on labor income, 55.6% (almost $124.5 million) of NASA Glenn's expenditures were allocated to professional, scientific and technical services; 22.6% ($50.5 million) was spent on administrative and support services; and 12.1% ($27 million) was spent on construction – the three largest groups of NASA Glenn expenditures in Northeast Ohio.[34] These three sectors constituted the largest categories of NASA Glenn spending in Northeast Ohio and, together, accounted for 90.2% of all NASA Glenn's FY 2013 expenditures in Northeast Ohio, excluding labor income. Among other expenditures, utilities accounted for 6.6%; education, wholesale and retail trade 1.1% each; and manufacturing, 0.6%. Other sectors' expenditures were less than 1%.

Businesses deriving the most benefit from spending by NASA Glenn personnel and other workers whose earnings are due, in part, to NASA Glenn's expenditures followed typical consumer spending patterns. These included businesses in the following industries: food services, accounting services, commercial banks, miscellaneous retailers, real estate companies, motor vehicle dealers, and hospitals and healthcare services.

[33] This is a very conservative estimate of the direct tax contribution NASA Glenn pays to all levels of government.

[34] Amounts in parentheses detailing percentage numbers are presented in 2013 dollars and correspond to appendix table A.3.

D.3. ECONOMIC IMPACT ON THE STATE OF OHIO, FY 2013

In this section, we describe the economic impact of NASA Glenn operations on Ohio's economy in FY 2013. The economic impact is presented through a detailed analysis of the change in taxes, output (sales), employment, labor income, and value added due to NASA Glenn's activities in Ohio. This section follows the structure of Section D.2., Economic Impact on Northeast Ohio, FY 2013.

D.3.1. Output Impact on the State of Ohio, FY 2013

The economic impact is assessed with IMPLAN multipliers illustrating buy-sell relationships between industries. The output multipliers measure the effect of NASA Glenn's spending on output (sales) across the state of Ohio. The multipliers applied to spending in Ohio are normally larger than the multipliers applied to expenditures in Northeast Ohio. This difference is due to a larger geographic area that allows for capturing of more purchases within the state compared to Northeast Ohio. It also enables more purchases from the state economy suppliers and, therefore, less leakage from the economy.

NASA Glenn's expenditures were divided into two categories: (1) spending on goods and services purchased from companies and other institutions located in the state of Ohio (local) and (2) spending on goods and services from businesses located outside of the state of Ohio. Local spending is then categorized by products made in the local economy, based on an IMPLAN classification system of industries that produced the products. Then, the spending is assigned to 440 IMPLAN sectors similar to the NAICS code industrial classification. Table A.4 in Appendix A provides a detailed list of NASA Glenn's expenditures by industry in the state of Ohio.

Table 11 presents the total output impact. The total amount of purchases for all NASA Glenn operations represented the direct output impact (change in final demand). Local expenditures and the contributions of individual industries that provided inputs to the producers of goods and services ultimately consumed by NASA Glenn represented indirect impact. Induced impact was estimated by measuring the spending of workers who were employed at NASA Glenn and supplying industries as a result of the Glenn's increased demand for products and services. Total output impact is the sum of direct impact, indirect impact, and induced impact. Table 11 reports output impacts by industry sector, illustrating how NASA Glenn's spending across Ohio affects different sectors of the state economy.

Table 11. Output Impact in the State of Ohio, FY 2013 (in 2014 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	$0	$361,217	$1,135,213	$1,496,430
Mining	$0	$1,047,198	$559,560	$1,606,758
Utilities	$0	$19,245,981	$7,915,389	$27,161,370
Construction	$0	$37,174,047	$2,784,597	$39,958,644
Manufacturing	$0	$11,423,363	$21,915,627	$33,338,990
Wholesale Trade	$0	$3,257,088	$17,472,040	$20,729,128
Retail trade	$0	$2,523,069	$35,607,049	$38,130,118
Transportation & Warehousing	$0	$4,378,096	$8,021,158	$12,399,254
Information	$0	$7,781,620	$12,814,006	$20,595,626
Finance & insurance	$0	$12,200,086	$38,657,578	$50,857,664
Real estate & rental	$0	$7,196,773	$62,353,855	$69,550,628
Professional- scientific & tech services	$0	$221,397,757	$12,347,479	$233,745,235
Management of companies	$0	$2,608,523	$3,283,192	$5,891,715
Administrative & waste services	$0	$75,588,552	$9,078,229	$84,666,781
Educational services	$0	$5,454,343	$6,214,845	$11,669,188
Health & social services	$0	$14,043	$62,170,933	$62,184,976
Arts- entertainment & recreation	$0	$1,122,224	$5,040,934	$6,163,158
Accommodation & food services	$0	$3,166,558	$19,217,085	$22,383,643
Other services	$0	$3,317,602	$14,373,615	$17,691,217
Government & non NAICs	$625,205,155	$1,852,999	$4,798,138	$631,856,292
TOTAL OUTPUT	$625,205,155	$421,111,140	$345,760,519	**$1,392,076,813**

Notes: Direct impact of NASA Glenn is a change in final demand that is applied to a sector of NASA Glenn's industry, NAICS 9271 – Space Research and Technology, which is a part of a larger industry sector NAICS 92 – Public Administration (Government & non-NAICs).
For output impact, the change in final demand or direct impact equals the spending of NASA Glenn for goods and services within and outside Ohio, including wages and benefits (reported in 2014 dollars).

The total output impact across the state of Ohio of NASA Glenn's spending on goods and services was $1,392 million in FY 2013. NASA Glenn's expenditures of $625.2 million resulted in an increase of $1,392 million in output (sales) across all industry sectors (Table 11). For example, NASA Glenn's spending affected a $233.8 million increase in sales (direct, indirect, and induced impacts) in professional, scientific, and technical services, as well as a $33.3 million increase in sales in the manufacturing sector.

Of the total output impact, 44.9% ($625.2 million) was accounted for by the change in final demand or direct impact that occurred because NASA Glenn's activities bring resources from outside of Ohio into the state. Approximately $421.1 million (30.3%) of the total output impact was a result of indirect spending by NASA Glenn on goods and services purchased within the state of Ohio. The remaining output impact of $345.8 million (24.8%) was due to the induced component as NASA Glenn's spending rippled throughout the state economy.[35]

An analysis of the IMPLAN model shows that the $766.9 million increase in sales generated by the indirect and induced impacts can be divided into the same broad categories that were identified for Northeast Ohio: NASA Glenn-driven industries ($417.8 million, 54.5%), consumer-driven industries ($267 million, 34.8%), and other industries ($82.1 million, 10.7%).[36]

The output distribution for select NASA Glenn-driven industries is shown in Figure 13. The output distribution for select consumer-driven industries is shown in Figure 14. The select industries shown in Figures 13 and 14 each added over $10 and $8 million, respectively.

The telecommunication industry in the state of Ohio saw an increase in revenue of $11.9 million in FY 2013 (Figure 13). This amount is the summation of the indirect and induced impacts generated primarily, but not exclusively, by NASA Glenn's spending. This increase of $11.9 million accounted for a 2.8% share of the $417.8 million increase in output value for all NASA Glenn-driven industries. Other industries shown in Figure 13 can be interpreted similarly.

The real estate establishments industry experienced a sales increase of $23.7 million in FY 2013 (Figure 14). This amount is the summation of the indirect and induced impact components generated primarily by NASA Glenn employees and other workers using real estate services. This increase of $23.7 million represented an 8.9% share of the $267 million increase in output for all consumer-driven industries. Other industries shown in Figure 14 can be interpreted similarly.

[35] All figures are reported in 2014 dollars.

[36] NASA Glenn-driven sectors include utilities, construction, information, education, professional and scientific services, and administrative and support services. Consumer-driven sectors include retail, healthcare, real estate, other services, owner-occupied buildings, finance and insurance, and entertainment and food.

Figure 13. Increase in Sales for Select NASA Glenn-Driven Industries in Ohio, FY 2013

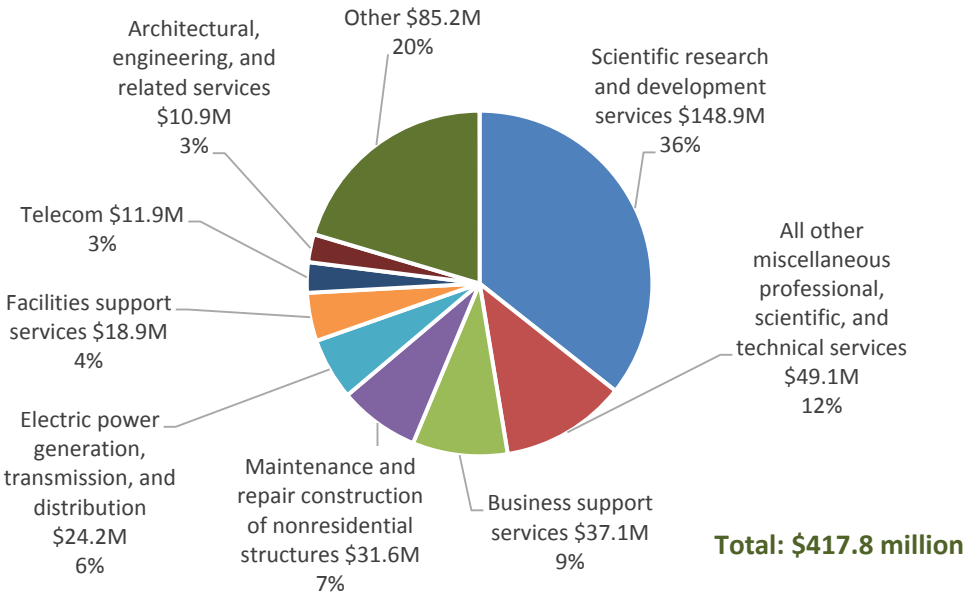
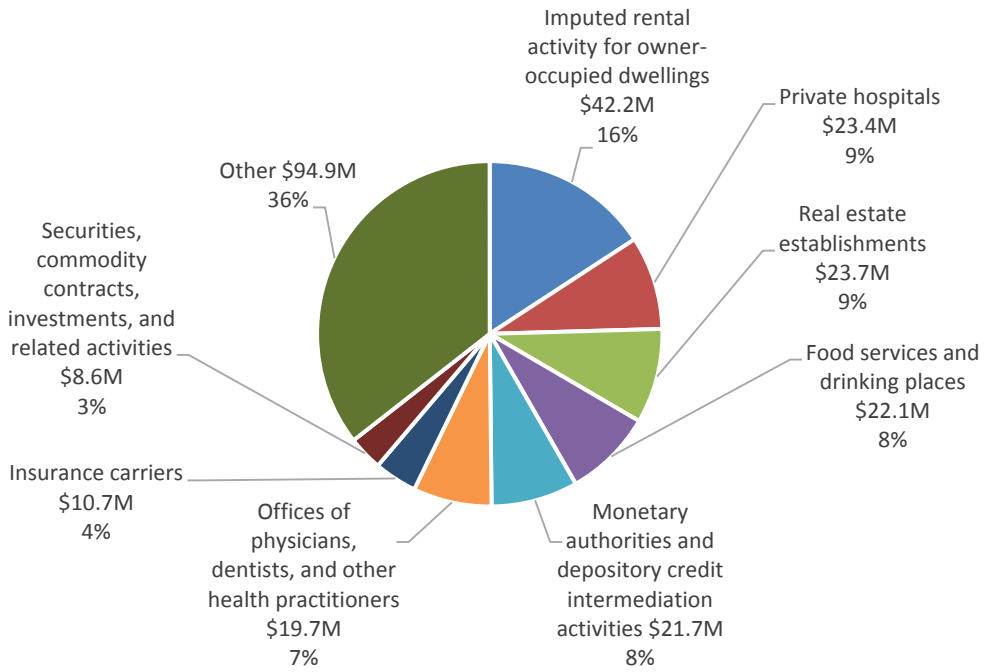


Figure 14. Increase in Sales for Select Consumer-Driven Industries in Ohio, FY 2013



D.3.2. Employment Impact on the State of Ohio, FY 2013

Spending for NASA Glenn's activities supported existing employment and the creation of new jobs in addition to their own employees (change in final demand or direct impact). NASA Glenn's spending created employment across the state of Ohio in the supply-chain industries from which it purchases goods and services (indirect impact).

In addition, money spent by NASA Glenn employees and employees of supply companies created jobs in various other industries (induced impact). The total employment impact equals the sum of NASA Glenn's employment (direct impact) and the indirect and induced components. Table 12 shows the number of jobs created by industry sector.

Table 12. Employment Impact in the State of Ohio, FY 2013

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	0	6	9	15
Mining	0	4	3	7
Utilities	0	21	9	29
Construction	0	266	19	285
Manufacturing	0	30	39	69
Wholesale Trade	0	16	85	101
Retail Trade	0	72	506	579
Transportation & Warehousing	0	30	59	89
Information	0	24	38	62
Finance & Insurance	0	48	162	210
Real estate & Rental	0	41	132	173
Professional- Scientific & Tech Services	0	1,200	97	1,297
Management of Companies	0	11	14	25
Administrative & Waste Services	0	1,029	144	1,173
Educational Services	0	68	105	174
Health & Social Services	0	0	631	631
Arts- Entertainment & Recreation	0	15	86	101
Accommodation & Food Services	0	56	343	399
Other Services	0	45	237	281
Government & non-NAICs*	1,664	14	35	1,713
TOTAL EMPLOYMENT	1,664	2,997	2,753	**7,414**

Notes: For employment impact, the change in final demand (direct impact) equals the number of NASA Glenn employees.

Employment increased by 7,414 jobs in Ohio in FY 2013 because of NASA Glenn's presence in the state. Of these 7,414 jobs, 1,664 people (22.4%) were directly employed at NASA Glenn. As a result of NASA Glenn's direct spending for goods and services purchased in Ohio and trickledown effect through their supply industries, 2,997 jobs (40.4%) were supported and created (indirect effect). The remaining employment—2,753 jobs (37.1%)—was the induced impact resulting from spending wages and salaries of NASA Glenn's workers and supply companies' employees through the state economy.

Of the 5,750 jobs created in Ohio due to the indirect and induced effects, 3,020 (52.5%) were found in NASA Glenn-driven sectors, 2,375 (41.3%) were in consumer-driven sectors, and 354 (6.2%) were created in other sectors.[37]

The job distribution for select NASA Glenn-driven industries is shown in Figure 15. The job distribution for select consumer-driven industries is shown in Figure 16. Each of the selected industries shown in Figures 15 and 16 added over 100 and 70 jobs, respectively.

Because of NASA Glenn's spending in Ohio, 536 jobs were added in business support services during FY 2013 (Figure 15). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily, but not exclusively, by NASA Glenn's need for business support services. The 536 jobs accounted for an 18% share of the 3,020 jobs that were created in all NASA Glenn-driven industries.

The private hospitals industry experienced an increase of 168 jobs in FY 2013 (Figure 16). The 168 jobs accounted for a 7% share of the 2,375 jobs that were created in all consumer-driven industries.

[37] Glenn-driven industries include utilities, construction, information, education, professional and scientific services, and administrative and support services. Consumer-driven industries include retail, healthcare, real estate, other services, owner-occupied buildings, finance and insurance, and entertainment and food.

Figure 15. Increase in Jobs for Select NASA Glenn-Driven Industries in Ohio, FY 2013

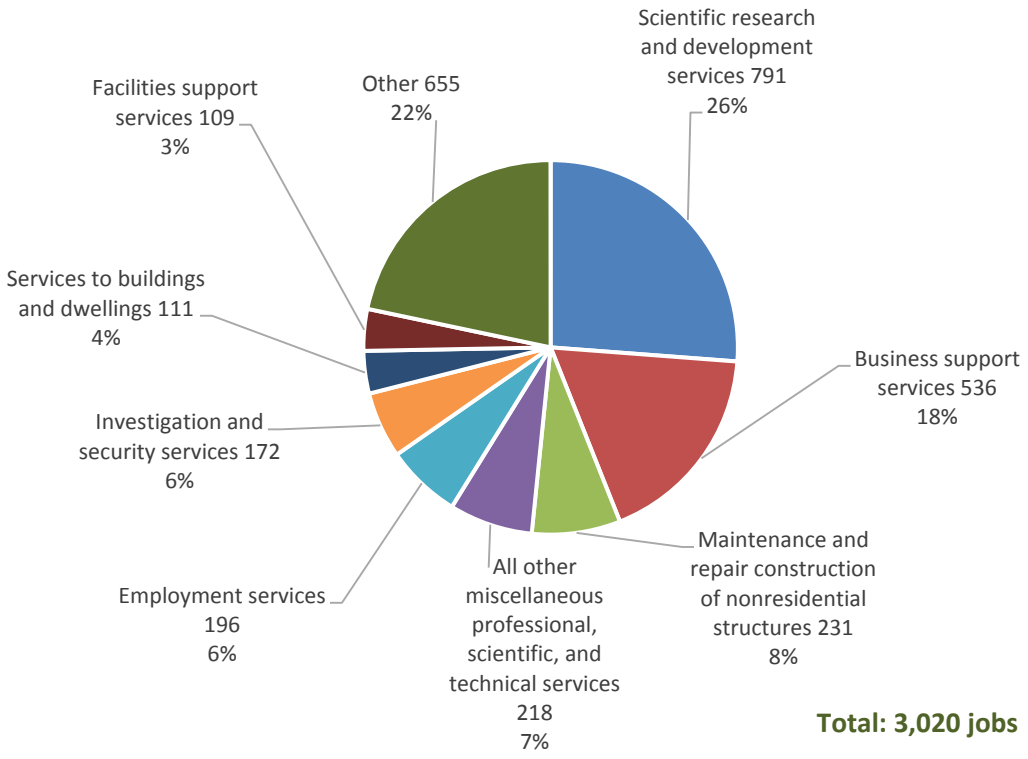
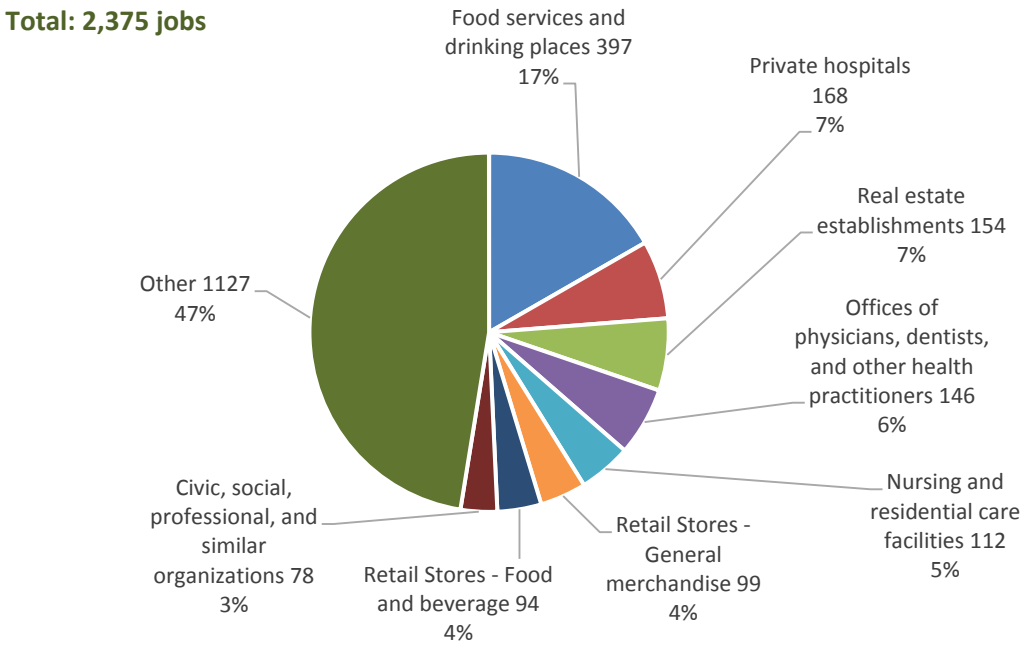


Figure 16. Increase in Jobs for Select Consumer-Driven Industries in Ohio, FY 2013



D.3.3 Labor Income Impact on the State of Ohio, FY 2013

Labor income is the estimated change in earnings received by employees of NASA Glenn and its supply companies in the state of Ohio due to NASA Glenn's spending on goods and services in the state. Wages and benefits paid to all NASA Glenn employees constituted the change in final demand or direct impact of NASA Glenn in Ohio measured in Labor Income.

Money paid to the employees of both the companies from which NASA Glenn buys its supplies and the suppliers of these companies represented the indirect earnings impact. Induced impact was generated through the spending of workers in all industries who were employed as a result of the increased demand for products and services created by NASA Glenn. Adding the direct, indirect, and induced impacts defines the total labor income impact of NASA Glenn. Table 13 shows the labor income impact by industry sector.

Table 13. Labor Income Impact in the State of Ohio, FY 2013 (in 2014 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing, Hunting	$0	$128,005	$407,859	$535,864
Mining	$0	$272,933	$147,173	$420,106
Utilities	$0	$3,011,301	$1,204,286	$4,215,587
Construction	$0	$15,438,966	$1,122,175	$16,561,141
Manufacturing	$0	$2,093,779	$2,683,128	$4,776,907
Wholesale Trade	$0	$1,261,732	$6,768,325	$8,030,057
Retail Trade	$0	$1,839,156	$16,331,730	$18,170,886
Transportation & Warehousing	$0	$1,577,796	$3,118,953	$4,696,749
Information	$0	$1,733,073	$2,500,416	$4,233,489
Finance & Insurance	$0	$2,865,242	$9,880,605	$12,745,847
Real Estate & Rental	$0	$1,195,855	$3,221,312	$4,417,167
Professional- Scientific & Tech services	$0	$108,560,144	$6,368,446	$114,928,590
Management of Companies	$0	$1,434,578	$1,805,618	$3,240,196
Administrative & Waste Services	$0	$40,199,598	$4,944,368	$45,143,967
Educational Services	$0	$2,787,620	$3,245,237	$6,032,857
Health & Social Services	$0	$6,538	$34,921,839	$34,928,377
Arts- Entertainment & Recreation	$0	$421,104	$2,043,615	$2,464,719
Accommodation & Food Services	$0	$1,171,240	$7,128,110	$8,299,350
Other Services	$0	$1,951,440	$7,948,871	$9,900,311
Government & non-NAICs	$224,093,222	$1,039,456	$2,469,020	$227,601,698
TOTAL LABOR INCOME	$224,093,222	$188,989,556	$118,261,087	**$531,343,865**

Notes: For labor income impact, the change in final demand or direct impact equals the wages and benefits paid to NASA Glenn employees.

Total labor income in the state of Ohio increased by $531.3 million as a result of NASA Glenn's spending on goods and services in FY 2013. Of this amount, $224.1 million (42.2%) included wages and benefits paid to NASA Glenn employees (change in final demand or direct impact). Monies paid to employees of companies across the state from which NASA Glenn buys its supplies and suppliers of those companies (indirect impact) represented $189 million (35.6%). The remaining earnings impact (induced component), estimated to be $118.3 million (22.3%), was the result of NASA Glenn's spending rippling through the Ohio economy via wages of Glenn's employees and wages of their supply companies.

Of the $307.3 million increase in labor income attributed to the indirect and induced impacts, $191.1 million (62.2%) was reported in Glenn-driven industries, $90.9 million (29.6%) occurred in consumer-driven industries, and $25.2 million (8.2%) was reported in other industries.[38]

The labor income distribution for select NASA Glenn-driven industries is shown in Figure 17. The labor income distribution for select consumer-driven industries is shown in Figure 18. The selected industries shown in these figures experienced the most gains in earnings (over $4.5 million and $2.5 million each in Figures 17 and 18, respectively).

In the NASA Glenn-driven industries, employees in scientific research and development services across the state of Ohio saw their labor income increase by $74.4 million in FY 2013 (Figure 17). These earnings are the summation of the indirect and induced impacts generated primarily, but not exclusively, by NASA Glenn's purchases of architectural and engineering services. The $74.4 million represented a 39% of the $191.1 million earnings increase that occurred in all NASA Glenn-driven industries.

Meanwhile, in the consumer-driven industries, employees working for the Offices of physicians, dentists, and other health practitioners industry experienced an increase in labor income of $12.7 million in FY 2013 (Figure 18). This amount is the summation of the indirect and induced impacts generated primarily by the spending of NASA Glenn employees and other workers at the offices of physicians and dentists. The $12.7 million accounted for a 14% share of the $90.9 million earnings increase that was reported by all consumer-driven industries.

[38] See section D.2.1. Output Impact on Northeast Ohio, FY 2011 for detailed definitions of NASA Glenn-driven, consumer-driven, and other industries.

Figure 17. Increase in Labor Income for Select NASA Glenn-Driven Industries in Ohio, FY 2013

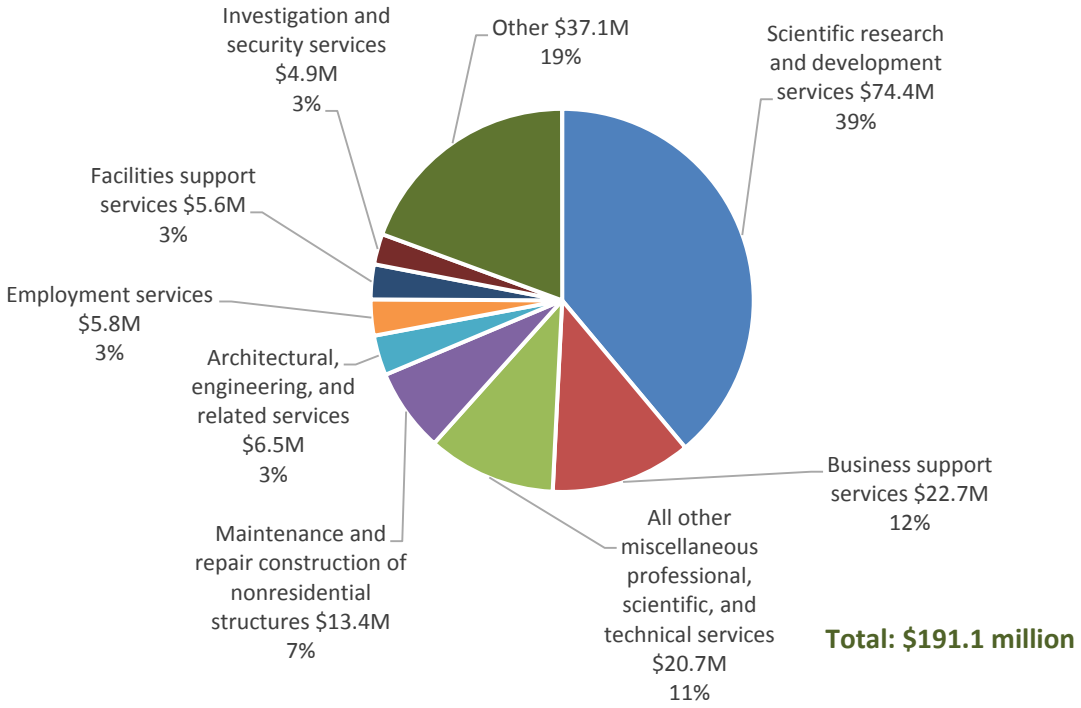
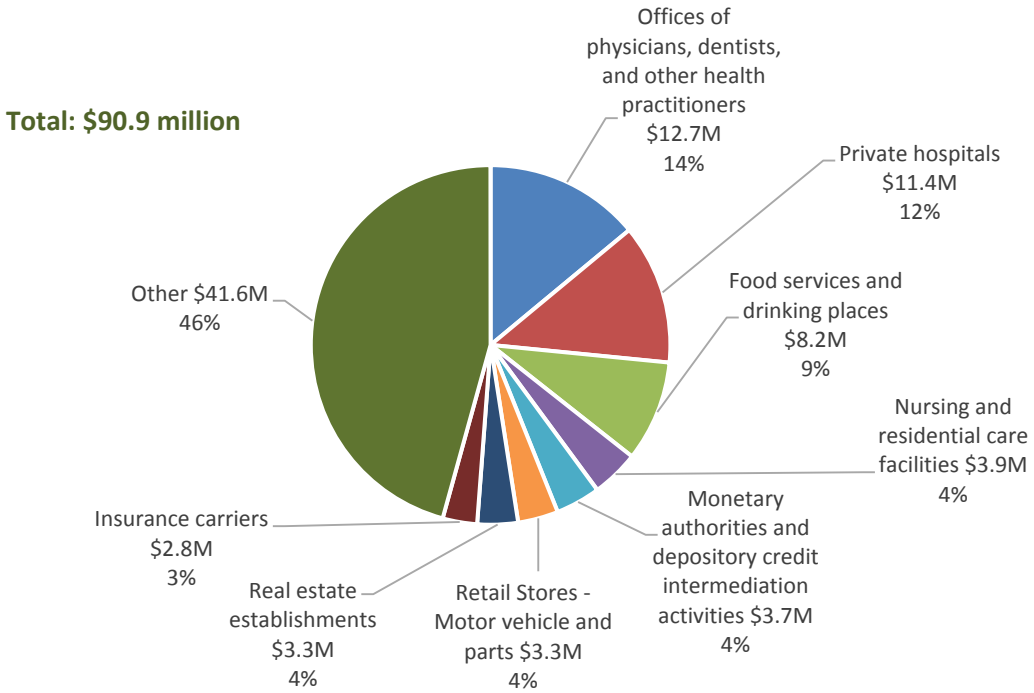


Figure 18. Increase in Labor Income for Select Consumer-Driven Industries in Ohio, FY 2013



D.3.4. Value Added Impact on the State of Ohio, FY 2013

NASA Glenn's spending created an increase of $828.2 million in value added for all industries.[39] Of this total amount, $356.4 million (43%) was the change in final demand or direct impact calculated as total output less intermediate expenditures. The largest portion of the value added is the wages and salaries paid to NASA Glenn employees. Another $257.5 million (31.1%) represented the value of goods and services, less intermediary goods, of companies in Ohio that supply to NASA Glenn (i.e., indirect impact). The remaining value added impact (induced component) was estimated at $214.3 million (25.9%). It occurred as a result of NASA Glenn's spending rippling through the Northeast Ohio economy. The total value added impact is a summation of the direct, indirect, and induced impacts (Table 14).

[39] "Value added" measures the economic impact of all goods and services produced in the state of Ohio due to NASA Glenn's operation (excluding intermediary goods). FY 2013's effect was significantly higher than the previous year due to an improved means of capturing the direct effect of value added. In calculating economic impact for FY 2012, total labor earnings were accounted for the direct value added impact.

Table 14. Value Added Impact in the State of Ohio, FY 2013 (in 2014 dollars)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	$0	$160,355	$502,790	$663,145
Mining	$0	$461,615	$144,681	$606,297
Utilities	$0	$12,747,384	$4,849,703	$17,597,086
Construction	$0	$15,632,919	$1,231,766	$16,864,685
Manufacturing	$0	$3,556,085	$5,191,911	$8,747,996
Wholesale Trade	$0	$2,155,405	$11,562,267	$13,717,673
Retail Trade	$0	$3,147,375	$26,490,373	$29,637,747
Transportation & Warehousing	$0	$2,439,456	$4,372,197	$6,811,654
Information	$0	$3,574,738	$6,113,362	$9,688,100
Finance & Insurance	$0	$7,752,974	$22,886,664	$30,639,638
Real Estate & Rental	$0	$5,497,600	$46,788,551	$52,286,151
Professional- Scientific & Tech Services	$0	$139,605,310	$9,014,148	$148,619,458
Management of Companies	$0	$1,693,273	$2,131,221	$3,824,494
Administrative & Waste Services	$0	$50,578,193	$6,117,263	$56,695,456
Educational Services	$0	$2,967,055	$3,799,288	$6,766,343
Health & Social Services	$0	$10,473	$38,968,976	$38,979,449
Arts- Entertainment & Recreation	$0	$600,205	$2,854,473	$3,454,678
Accommodation & Food Services	$0	$1,676,172	$10,176,130	$11,852,302
Other Services	$0	$2,108,655	$8,793,931	$10,902,585
Government & non-NAICs*	$356,366,938	$1,143,389	$2,321,871	$359,832,197
TOTAL VALUE ADDED	$356,366,938	$257,508,631	$214,311,567	**$828,187,136**

Notes: For value added impact, the change in final demand (direct impact) equals total output less the intermediate expenditures.

Total value added in the state of Ohio increased by $828.2 million as a result of NASA Glenn's spending on goods and services in FY 2013. Of this total amount, $356.4 million (43%) included the wages and benefits paid directly to NASA Glenn employees (change in final demand or direct impact). Another $257.5 million (31.1%) represented the value of goods and services (less intermediary goods) companies in Ohio to NASA Glenn (indirect impact). The remaining value added impact (induced component), estimated to be $214.3 million (25.9%), occurred as the effects of NASA Glenn's spending rippled through the Ohio economy.

Of the $471.8 million increase in value added generated across Ohio due to the indirect and induced impacts, $195.9 million (41.5%) was reported in NASA Glenn-driven industries, $145 (30.7%) was generated in consumer-driven industries, and $130.9 million (27.7%) was reported in other industries.[40]

The value added distribution for select NASA Glenn-driven industries is shown in Figure 19. The value added distribution for select consumer-driven industries is shown in Figure 20. Selected industries in Figure 19 and Figure 20 each added over $12 and $11 million, respectively.

Within the NASA Glenn-driven industries, persons engaged in miscellaneous professional, scientific and technical services saw the sector's value added increase by $39.2 million in FY 2013 (Figure 19). This increase is a result of the summation of the indirect and induced impacts generated primarily, but not exclusively, by NASA Glenn's spending on miscellaneous professional, scientific, and technical services. The $39.2 million accounted for 15% of the $256.2 million value added increase that was reported by all NASA Glenn-driven industries. In the consumer-driven industries, employees of the monetary authorities saw the industry's value added increase by $16.5 million in FY 2013 (Figure 20). This increase is a result of the summation of the indirect and induced impacts generated by consumer spending on monetary authorities. The increase of $16.5 million accounted for 9% of the $177.8 million value added increase that occurred in all consumer-driven industries.

[40] See section D.2.1 Output Impact on Northeast Ohio, FY 2011 for definitions of NASA Glenn-driven, consumer-driven, and other industries.

Figure 19. Increase in Value Added for NASA Glenn-Driven Industries in Ohio, FY 2013

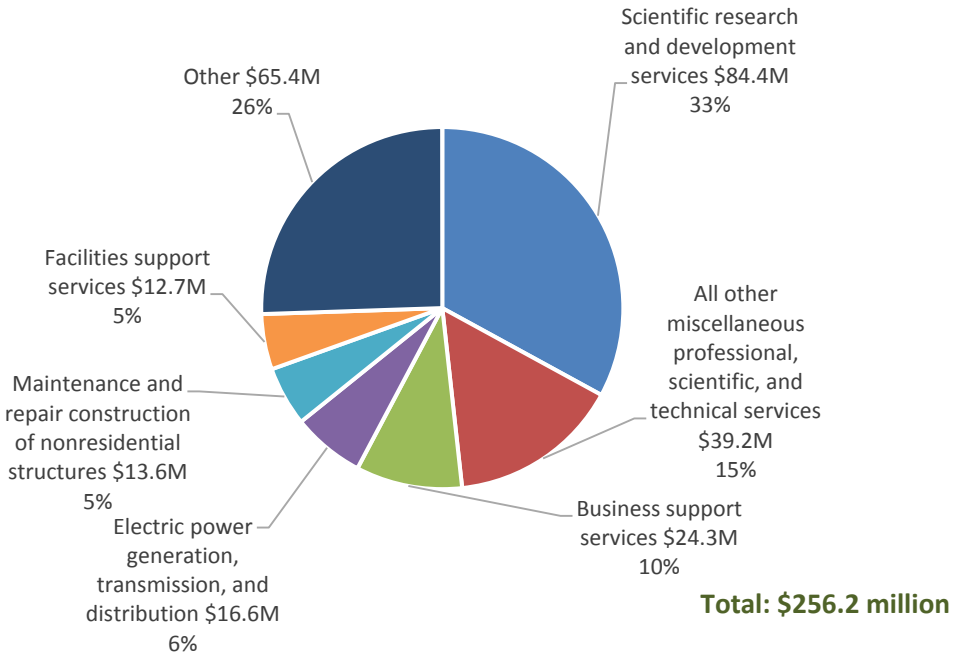
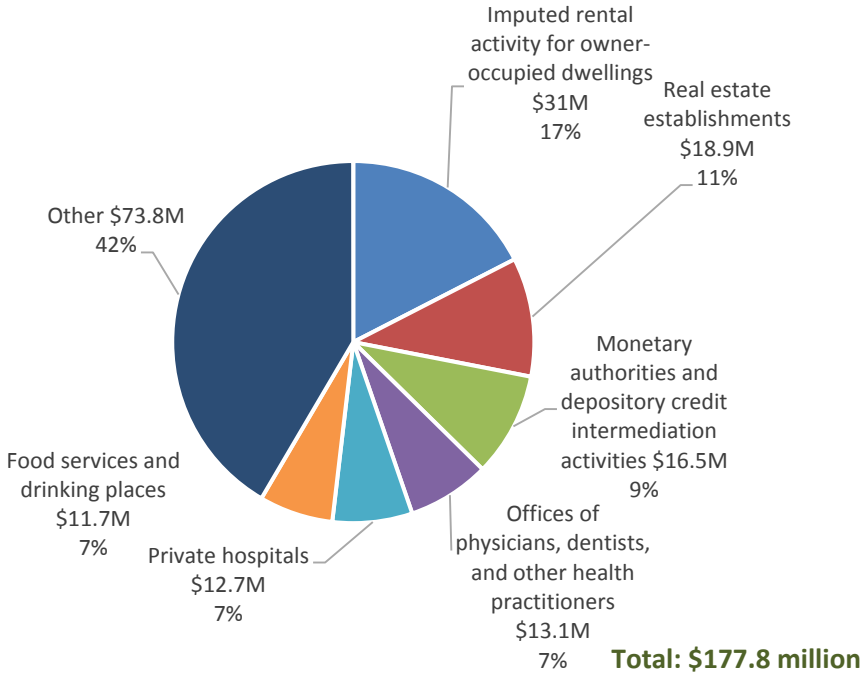


Figure 20. Increase in Value Added for Consumer-Driven Industries in Ohio, FY 2013



D.3.5. Tax Impact on the State of Ohio, FY 2013

NASA Glenn's operation and economic impact on the state of Ohio in FY 2013 increased tax revenues by a total of $103.1 million. Of that amount, direct tax impact was $9.5 million in Glenn's employee taxes on wages, $47.1 million indirect tax impact, and $46.5 million – induced tax impact. [41]

D.3.6. FY 2013 Ohio Impact Summary

The economic activity of NASA Glenn generated the following impact on the state of Ohio (adjusted to 2014 dollars):

- Total Output Impact: $1,392 M
- Total Employment Impact: 7,414 jobs
- Total Labor Income Impact: $531.3 M
- Total Value Added Impact: $828.2 M
- Total Tax Impact: $103.1 M

The impact of NASA Glenn's expenditures on the state of Ohio is slightly higher than the impact on Northeast Ohio because the models capture more buy-sell relationships in the larger geographic area. The majority of NASA Glenn's expenditures in Ohio were spent in Northeast Ohio.

In FY 2013, NASA Glenn's expenditures in the state of Ohio were $503.2 million (only $58.8 million more than in Northeast Ohio, in 2014 dollars).

NASA Glenn decreased the total spending in Ohio in FY 2013 compared to FY 2012 by $19 million (in 2013 dollars). Almost $14 million of this decrease was in Ohio's scientific research and development services sector (almost 10% cut). Due to the decreased overall spending in Ohio, a majority of sectors experienced proportional decline.

Compared to the expenditures made in Northeast Ohio in FY 2013, the largest share of the total payments was spent on professional, scientific, and technical services in Ohio (62.5% in Ohio, compared to 55.6% in Northeast Ohio. More than 96.1% of NASA Glenn spending in Ohio ($264 million), excluding labor income, went to the following industry sectors: professional, scientific and technical services ($171.7 million); administrative and support services ($50.5 million); construction ($27 million); and utilities ($14.8 million).[42] Additionally, 1.6% ($4.3 million) went toward the education sector and 0.8% ($2.3 million) for manufacturing.

NASA Glenn's statewide expenditures are similar to the expenditures in Northeast Ohio. Businesses deriving the most benefit from spending by NASA Glenn personnel and other workers whose earnings are due in part to NASA Glenn's expenditures followed typical consumer spending patterns. These businesses include the following industries: food services, accounting services, commercial banks, miscellaneous retailers, real estate companies, motor vehicle dealers, and hospitals and healthcare services.

[41] This is a very conservative estimate of the direct tax contribution NASA Glenn pays to all levels of government.

[42] Amounts in parentheses detailing percentage numbers are presented in 2013 dollars and correspond to Appendix table A.4.

APPENDIX A: DATA TABLES

Table A.1. NASA Glenn Spending by State, Excluding Payroll, FY 2013

State	Spending	Share
Ohio	$274,636,679	69.38%
California	$21,213,818	5.36%
Maryland	$17,104,104	4.32%
Virginia	$9,632,080	2.43%
Connecticut	$7,328,509	1.85%
Massachusetts	$7,011,483	1.77%
Pennsylvania	$5,398,228	1.36%
Missouri	$5,050,893	1.28%
New York	$4,623,706	1.17%
Texas	$4,001,994	1.01%
Michigan	$3,723,597	0.94%
Florida	$3,533,112	0.89%
New Jersey	$3,436,686	0.87%
Arizona	$3,396,761	0.86%
Indiana	$2,641,733	0.67%
Colorado	$2,599,061	0.66%
Illinois	$1,947,008	0.49%
District of Columbia	$1,946,877	0.49%
Georgia	$1,799,495	0.45%
Alabama	$1,618,312	0.41%
Minnesota	$1,427,871	0.36%
Iowa	$1,411,640	0.36%
Utah	$936,358	0.24%
Tennessee	$936,234	0.24%
Wisconsin	$796,831	0.20%
North Carolina	$762,686	0.19%
Kansas	$674,719	0.17%
Arkansas	$585,572	0.15%
New Hampshire	$529,371	0.13%
Kentucky	$413,710	0.10%
Idaho	$400,202	0.10%
Oregon	$399,368	0.10%

State	Spending	Share
Washington	$395,083	0.10%
Delaware	$383,935	0.10%
Wyoming	$315,887	0.08%
Montana	$264,631	0.07%
New Mexico	$224,740	0.06%
Mississippi	$208,349	0.05%
Rhode Island	$206,347	0.05%
South Dakota	$205,203	0.05%
South Carolina	$193,166	0.05%
Puerto Rico	$182,432	0.05%
NE Total	$172,740	0.04%
Nevada	$132,314	0.03%
Oklahoma	$125,762	0.03%
West Virginia	$100,480	0.03%
Louisiana	$54,756	0.01%
Vermont	$17,010	0.00%
Maine	$9,133	0.00%
Hawaii	$493	0.00%
Canada	$404,073	0.10%
United Kingdom	$224,777	0.06%
France	$53,260	0.01%
Sweden	$21,700	0.01%
Germany	$20,552	0.01%
Switzerland	$19,536	0.00%
New Zealand	$11,205	0.00%
Australia	$1,308	0.00%
Hungary	$400	0.00%
Singapore	$188	0.00%
Qatar	$66	0.00%
Outside U.S.	*$757,064*	*0.19%*
Total	**$395,868,222**	**100.00%**

Table A.2. NASA Glenn Funding Allocated to Academic Institutions by State, FY 2013

State	Amount	Share
Ohio	$4,309,854	26.54%
Massachusetts	$2,106,627	12.97%
California	$1,650,092	10.16%
Indiana	$1,039,087	6.40%
Maryland	$998,043	6.15%
Pennsylvania	$809,916	4.99%
Illinois	$668,887	4.12%
Michigan	$542,746	3.34%
Kentucky	$513,498	3.16%
Texas	$420,850	2.59%
Missouri	$332,788	2.05%
New Jersey	$285,975	1.76%
New York	$246,315	1.52%
Georgia	$242,632	1.49%
Iowa	$239,495	1.47%
North Carolina	$237,636	1.46%
Alabama	$208,765	1.29%
Oregon	$198,955	1.23%
Mississippi	$188,848	1.16%
Puerto Rico	$182,432	1.12%
Delaware	$161,466	0.99%
Florida	$145,242	0.89%
Connecticut	$112,957	0.70%
Tennessee	$99,914	0.62%
Virginia	$69,503	0.43%
West Virginia	$67,809	0.42%
Arizona	$50,000	0.31%
New Mexico	$40,836	0.25%
Colorado	$36,860	0.23%
Kansas	$13,429	0.08%
Washington	$13,388	0.08%
Utah	$3,641	0.02%
Hawaii	$493	0.00%
Total	**$16,238,977**	**100.00%**

Note: Academic institutions in eighteen states and the District of Columbia did not receive NASA Glenn grants in 2013.

Table A.3. NASA Glenn Detailed Expenditures in Northeast Ohio, FY 2013

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Utilities			**$14,743,701**
	Electric power generation, transmission, and distribution	31	$14,009,618
	Natural gas distribution	32	$709,666
	Water, sewage and other treatment and delivery systems	33	$24,417
Construction			**$26,988,734**
	Construction of other new nonresidential structures	36	$6,459,633
	Maintenance and repair construction of nonresidential structures	39	$20,488,328
	Maintenance and repair construction of residential structures	40	$40,774
Manufacturing			**$1,344,541**
	Printing	113	$1,142
	Industrial gas manufacturing	121	$33,375
	Other plastics product manufacturing	149	$4,435
	Miscellaneous, nonmetallic mineral products	169	$30,668
	Plate work and fabricated structural product manufacturing	186	$38,917
	Machine shops	195	$218,747
	Valve and fittings other than plumbing	198	$83,818
	Fabricated pipe and pipe fitting manufacturing	201	$1,240
	Other fabricated metal manufacturing	202	$3,495
	Metal cutting and forming machine tool manufacturing	218	$112,000
	Mechanical power transmission equipment manufacturing	224	$4,695
	Material handling equipment manufacturing	228	$11,483
	Industrial process furnace and oven manufacturing	232	$23,560
	Audio and video equipment manufacturing	240	-$1,332
	Other electronic component manufacturing	247	$153,916
	Industrial process variable instruments manufacturing	251	$31,541
	Totalizing fluid meters and counting devices manufacturing	252	$4,277
	Electricity and signal testing instruments manufacturing	253	$35,223
	Analytical laboratory instrument manufacturing	254	$1,701
	Watch, clock, and other measuring and controlling device manufacturing	256	$2,000
	Motor and generator manufacturing	267	$37,180
	Relay and industrial control manufacturing	269	$18,394

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	All other miscellaneous electrical equipment and component manufacturing	275	$26,236
	Other aircraft parts and auxiliary equipment manufacturing	286	$467,828
Wholesale & Retail Trade			**$2,457,816**
	Wholesale trade businesses	319	$271,163
	Retail - Electronics and appliances	322	$55,051
	Retail - Miscellaneous	330	$2,131,603
Transportation			**$30,049**
	Transport by truck	335	$30,049
Information & Telecommunication			**$21,811**
	Book publishers	343	$6,790
	Telecommunications	351	$15,021
Real Estate and Rental & Leasing			**$174,815**
	Real estate	360	$14,960
	General and consumer goods rental except video tapes and discs	363	$2,011
	Commercial and industrial machinery and equipment rental and leasing	365	$157,845
Professional, Scientific, & Technical Services			**$124,491,331**
	Legal services	367	$12,110
	Accounting, tax preparation, bookkeeping, and payroll services	368	$11,200
	Architectural, engineering, and related services	369	$4,632,175
	Other computer-related services, including facilities management	373	$457,067
	Management, scientific, and technical consulting services	374	$7,839
	Scientific research and development services	376	$80,722,983
	All other miscellaneous professional, scientific, and technical services	380	$38,647,959
Administrative & Support and Waste Management Services			**$50,504,335**
	Facilities support services	385	$14,879,250
	Business support services	386	$29,670,574
	Investigation and security services	387	$5,742,062
	Other support services	389	$1,400
	Waste management and remediation services	390	$211,050

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Education			**$2,534,114**
	Private junior colleges, colleges, universities, and professional schools	392	$2,524,764
	Other educational services	393	$9,350
Health Care & Social Assistance			**$10,583**
	Medical and diagnostic labs and outpatient and other ambulatory care services	396	$10,583
Arts, Entertainment & Recreation			**$493,885**
	Museums, historical sites, zoos, and parks	406	$493,885
Other Services			**$26,543**
	Electronic and precision equipment repair and maintenance	416	$19,400
	Commercial and industrial machinery and equipment repair and maintenance	417	$7,143
Labor Income			**$216,910,663**
	Employee compensation	5001	$216,910,663
TOTAL EXPENDITURES in Northeast Ohio			**$440,732,924**

Notes:

a. Sector: Industry classification code used by IMPLAN. It is analogous to the North American Industry Classification System (NAICS). IMPLAN provides a cross-reference table bridging their sector numbers and NAICS codes.

b. Expenditure: Actual dollar value for a product or service spent by NASA Glenn in FY 2013. Values shown in Table A-3 are limited to expenditures made in Northeast Ohio.

c. Labor Income: Labor income includes wages and benefits of Glenn employees living in Northeast Ohio and accounts for commuters' local spending.

All expenditures in this table are presented in 2013 dollars.

Table A.4. NASA Glenn Detailed Expenditures in the State of Ohio, FY 2013

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Utilities			**$14,801,312**
	Electric power generation, transmission, and distribution	31	$14,009,618
	Natural gas distribution	32	$709,666
	Water, sewage and other treatment and delivery systems	33	$82,027
Construction			**$26,988,734**
	Construction of other new nonresidential structures	36	$6,459,633
	Maintenance and repair construction of nonresidential structures	39	$20,488,328
	Maintenance and repair construction of residential structures	40	$40,774
Manufacturing			**$2,281,268**
	Printing	113	$1,435
	Industrial gas manufacturing	121	$33,375
	Other basic organic chemical manufacturing	126	$31,500
	Polystyrene foam product manufacturing	146	$26,760
	Other plastics product manufacturing	149	$251,302
	Miscellaneous nonmetallic mineral products	169	$30,668
	Plate work and fabricated structural product manufacturing	186	$52,042
	Machine shops	195	$331,834
	Coating, engraving, heat treating, and allied activities	197	$6,369
	Valve and fittings other than plumbing	198	$83,818
	Fabricated pipe and pipe fitting manufacturing	201	$150,678
	Other fabricated metal manufacturing	202	$8,780
	Metal cutting and forming machine tool manufacturing	218	$151,580
	Mechanical power transmission equipment manufacturing	224	$6,380
	Material handling equipment manufacturing	228	$11,483
	Other general purpose machinery manufacturing	230	$26,375
	Industrial process furnace and oven manufacturing	232	$29,200
	Audio and video equipment manufacturing	240	-$1,332
	Other electronic component manufacturing	247	$157,740
	Industrial process variable instruments manufacturing	251	$31,541
	Totalizing fluid meters and counting devices manufacturing	252	$4,277
	Electricity and signal testing instruments manufacturing	253	$42,023
	Analytical laboratory instrument manufacturing	254	$35,122
	Watch, clock, and other measuring and controlling device manufacturing	256	$2,000
	Motor and generator manufacturing	267	$37,239

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Relay and industrial control manufacturing	269	$18,394
	Wiring device manufacturing	273	$7,851
	All other miscellaneous electrical equipment and component manufacturing	275	$57,153
	Aircraft engine and engine parts manufacturing	285	$26,402
	Other aircraft parts and auxiliary equipment manufacturing	286	$476,508
	All other transportation equipment manufacturing	294	$142,854
	Office furniture and custom architectural woodwork and millwork manufacturing	301	$9,916
Wholesale & Retail Trade			**$2,878,808**
	Wholesale trade businesses	319	$460,971
	Retail - Electronics and appliances	322	$55,051
	Retail - Miscellaneous	330	$2,362,786
Transportation			**$30,267**
	Transport by truck	335	$30,267
Information & Telecommunication			**$21,811**
	Book publishers	343	$6,790
	Telecommunications	351	$15,021
Real Estate and Rental & Leasing			**$175,351**
	Real estate	360	$14,960
	General and consumer goods rental except video tapes and discs	363	$2,011
	Commercial and industrial machinery and equipment rental and leasing	365	$158,381
Professional, Scientific, & Technical Services			**$171,704,938**
	Legal services	367	$114,978
	Accounting, tax preparation, bookkeeping, and payroll services	368	$11,200
	Architectural, engineering, and related services	369	$5,415,914
	Other computer-related services, including facilities management	373	$461,680
	Management, scientific, and technical consulting services	374	$26,489
	Scientific research and development services	376	$126,992,019
	All other miscellaneous professional, scientific, and technical services	380	$38,682,659
Administrative & Support and Waste Management Services			**$50,516,923**
	Facilities support services	385	$14,891,838
	Business support services	386	$29,670,574
	Investigation and security services	387	$5,742,062

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Other support services	389	$1,400

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Waste management and remediation services	390	$211,050
Education			**$4,319,204**
	Private junior colleges, colleges, universities, and professional schools	392	$4,309,854
	Other educational services	393	$9,350
Health Care & Social Assistance			**$10,583**
	Medical and diagnostic labs and outpatient and other ambulatory care services	396	$10,583
Arts, Entertainment & Recreation			**$493,885**
	Museums, historical sites, zoos, and parks	406	$493,885
Other Services			**$113,546**
	Electronic and precision equipment repair and maintenance	416	$66,086
	Commercial and industrial machinery and equipment repair and maintenance	417	$12,460
	Grantmaking, giving, and social advocacy organizations	424	$35,000
Government Services (c)			**$300,049**
	Other Federal Government enterprises	429	$300,049
Labor Income			**$224,376,162**
	Employee compensation	5001	$224,376,162
TOTAL EXPENDITURES in Ohio			**$499,012,841**

Notes:

a. Sector: Industry classification code used by IMPLAN. It is analogous to the North American Industry Classification System (NAICS). IMPLAN provides a cross-reference table bridging their sector numbers and NAICS codes.

b. Expenditure: Actual dollar value for a product or service spent by NASA Glenn in FY 2013. Values shown in Table A-4 are limited to expenditures made in Ohio.

c. Labor Income: Labor income includes wages and benefits of Glenn employees living in Ohio and accounts for commuters' local spending.

All expenditures in this table are presented in 2013 dollars.